(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号

特開平9－114955

(43)公開日　平成9年(1997)5月2日

(51)Int.Cl.⁶	識別記号	庁内整理番号	ＦＩ		技術表示箇所
Ｇ０６Ｍ　7/00			Ｇ０６Ｍ	7/00	
Ａ６１Ｂ　5/0245			Ｇ０４Ｇ	1/00	３１５Ｄ
Ｇ０４Ｇ　1/00	３１５		Ａ６１Ｂ	5/02	３１０Ｆ
					３２０Ｂ
					３２２

審査請求　未請求　請求項の数５　ＯＬ　（全 15 頁）

(21)出願番号　特願平7－270394

(22)出願日　平成7年(1995)10月18日

(71)出願人　000002369
セイコーエプソン株式会社
東京都新宿区西新宿２丁目４番１号

(71)出願人　000002325
セイコー電子工業株式会社
千葉県千葉市美浜区中瀬１丁目８番地

(72)発明者　早川　求
長野県諏訪市大和３丁目３番５号　セイコーエプソン株式会社内

(72)発明者　中村　千秋
千葉県千葉市美浜区中瀬１丁目８番地　セイコー電子工業株式会社内

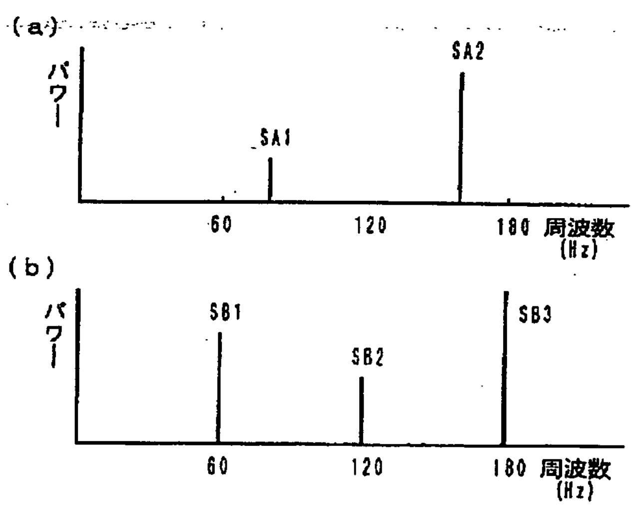
(74)代理人　弁理士　鈴木　喜三郎　（外１名）

(54)【発明の名称】　ピッチ計

(57)【要約】

【課題】　走行時及び歩行時のいずれにおいてもピッチを計測でき、しかも、走る場合と歩く場合との間で条件設定を切り換えるための外部操作が不必要なピッチ計を提供すること。

【解決手段】　携帯用電子機器のピッチ演算部では、体動信号を周波数分析した後のスペクトラムにおいて、１００回／分以上の領域に出現した高レベルの線スペクトルＳＡ２、ＳＢ３は、走行時の基本波に対する第２高調波か、あるいは、歩行時の基本波に対する第３高調波のいずれかである。そこで、線スペクトルＳＡ２、ＳＢ３が第２高調波か、あるいは第３高調波であるかを求め、第２高調波としての信号であると判断したときにその周波数からピッチを求め、第３高調波としての信号であると判断したときにその周波数の２／３倍に相当する値からピッチを求める。



【特許請求の範囲】

【請求項１】　体動を検出する体動センサと、この体動センサの検出結果に周波数分析を行う周波数分析手段と、この周波数分析手段の分析結果において、所定の周波数以上の領域でパワーが所定のレベル以上にある信号をピッチを求めるための基準波として特定するとともに、該基準波が体動の基本波に対する第２高調波であるか第３高調波であるかを判断し、該基準波が第２高調波であると判断したときにその周波数からピッチを求め、該基準波が第３高調波であると判断したときにその周波数の２／３倍に相当する値からピッチを求めるピッチ演算手段とを有することを特徴とするピッチ計。

【請求項２】　請求項１において、前記ピッチ演算手段は、前記基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第１波確認手段と、該第１波確認手段が前記基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号がないと判断したときには前記基準波を前記基本波に対する第２高調波であると判断する信号判別手段とを備えていることを特徴とするピッチ計。

【請求項３】　請求項１において、前記ピッチ演算手段は、前記基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第２波確認手段と、該第２波確認手段が前記基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号がないと判断したときには前記基準波を前記基本波に対する第２高調波であると判断する信号判別手段とを備えていることを特徴とするピッチ計。

【請求項４】　請求項２において、前記ピッチ演算手段は、前記基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第２波確認手段を有し、前記信号判別手段は、前記第１波確認手段が前記基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号がないと判断し、かつ、前記第２波確認手段が前記基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号がないと判断したときには、前記基準波を前記基本波に対する第２高調波であると判断するように構成されていることを特徴とするピッチ計。

【請求項５】　請求項２ないし４のいずれかの項において、前記信号判別手段は、前記基準波の周波数の所定の倍数に相当する周波数を有する高レベルの信号があるか否かの確認結果に基づいて前記基準波を前記基本波に対する第３高調波であると判断し、かつ、前記基準波が所定の周波数レベル以上にあると判断したときに、前記基準波は前記基本波に対する第３高調波であると断定するように構成されていることを特徴とするピッチ計。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、ピッチ計に関し、更に詳しくは、走行時または歩行時に検出した体動信号からピッチを求めるための技術に関するものである。

【０００２】

【従来の技術】ピッチ計では、それに内蔵されている加速度センサなどによって体動信号を検出し、この体動信号からピッチを求めている。たとえば、体動信号を増幅した後に、パルス変換すると、図１４（ａ）に示すパルス波形が得られる。このようにして得られたパルス波形では、走行状態によりパルス間隔が不規則であることから、所定のしきい値を設定してパルスをカウントする方法があるが、誤差が大きい。そこで、図１４（ｂ）に示すように、パルスをカウントする際に、マスク時間を設定することによって、パルスを２発単位でカウントし、検出精度を上げる方法が用いられている。たとえば、走行時のピッチは、期間Ｔ１～Ｔ２に示すように、通常１５０回／分～２００回／分であり、パルス周期で０．４秒～０．３秒であることから、マスク時間を０．５秒に設定することにより、パルス周期が０．８秒～０．６秒のパルスとしてカウントすれば、パルスを２発単位でカウントすることになる。

【０００３】

【発明が解決しようとする課題】しかしながら、従来のピッチ計では、走行時のピッチに合わせてマスク時間を設定しているため、歩行時のピッチを計測できないという問題点がある。すなわち、歩行時では、図１４（ｂ）に期間Ｔ３～Ｔ４で示すように、パルス周期が０．６秒～０．４秒になるため、マスク時間を０．５秒に設定すると、ピッチが１００回／分のときには、１発目のパルスをカウントしてしまい、ピッチを誤表示してしまう。

【０００４】そこで、従来のピッチ計では、走行時及び歩行時のいずれのピッチをも計測しようとすると、走る場合と歩く場合とでマスク時間の設定を切り換える外部操作が必要であり、使い勝手がわるいという問題点がある。

【０００５】以上の問題点に鑑みて、本発明の課題は、走行時及び歩行時のいずれにおいてもピッチを計測でき、しかも、走る時と歩く時との間で条件設定を切り換えるための外部操作が不必要なピッチ計を提供することにある。

【０００６】

【課題を解決するための手段】上記課題を解決するために、本発明に係るピッチ計では、体動を検出する体動センサと、この体動センサの検出結果に周波数分析を行う周波数分析手段と、この周波数分析手段の分析結果において、所定の周波数以上の領域でパワーが所定のレベル以上にある信号をピッチを求めるための基準波として特定するとともに、該基準波が体動の基本波に対する第２高調波であるか第３高調波であるかを判断し、該基準波が第２高調波であると判断したときにその周波数からピッチを求め、該基準波が第３高調波であると判断したと

3

きにその周波数の２／３倍に相当する値からピッチを求めるピッチ演算手段とを有することを特徴とする。

【０００７】本発明において、前記ピッチ演算手段は、たとえば、前記基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第１波確認手段と、該第１波確認手段が前記基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号がないと判断したときには前記基準波を前記基本波に対する第２高調波であると判断する信号判別手段とを備えるように構成する。

【０００８】また、前記ピッチ演算手段は、前記基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第２波確認手段と、該第２波確認手段が前記基準波の周波数の２／３倍は相当する周波数を有する高レベルの信号がないと判断したときには前記基準波を前記基本波に対する第２高調波であると判断する信号判別手段とを備えるように構成する。

【０００９】また、前記ピッチ演算手段は、前記基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第１波確認手段と、前記基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第２波確認手段とを有し、前記信号判別手段は、前記第１波確認手段が前記基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号がないと判断し、かつ、前記第２波確認手段が前記基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号がないと判断したときには、前記基準波を前記基本波に対する第２高調波であると判断するように構成してもよい。

【００１０】本発明において、前記信号判別手段は、前記基準波の周波数の所定の倍数に相当する周波数を有する高レベルの信号があるか否かの確認結果に基づいて前記基準波を前記基本波に対する第３高調波であると判断し、かつ、前記基準波が所定の周波数レベル以上にあると判断したときに、前記基準波は前記基本波に対する第３高調波であると断定するように構成することが好ましい。

【００１１】

【発明の実施の形態】図面に基づいて、本発明の一実施例を説明する。

【００１２】（全体構成）図１は、本例の携帯用電子機器（ピッチ計）の構成を示す説明図である。

【００１３】図１において、本例の携帯用電子機器１は、腕時計構造を有する装置本体１０と、この装置本体１０に接続されるケーブル２０と、このケーブル２０の先端側に設けられた脈波検出用センサユニット３０とから大略構成されている。ケーブル２０の先端側にはコネクタピース８０が構成されており、このコネクタピース８０は、装置本体１０の６時の側に構成されているコネクタ部７０に対して着脱自在である。装置本体１０には、腕時計における１２時方向から腕に巻きついてその６時方向で固定されるリストバンド１２が設けられ、このリストバンド１２によって、装置本体１０は、腕に着脱自在である。脈波検出用センサユニット３０は、センサ固定用バンド４０によって遮光されながら人差し指の根元から指関節までの間に装着されている。このように、脈波検出用センサユニット３０を指の根元に装着すると、ケーブル２０が短くて済むので、ケーブル２０は、ランニング中に邪魔にならない。また、掌から指先までの体温の分布を計測すると、寒いときには、指先の温度が著しく低下するのに対し、指の根元の温度は比較的低下しない。従って、指の根元に脈波検出用センサユニット３０を装着すれば、寒い日に屋外でランニングしたときでも、脈拍数などを正確に計測できる。

4

【００１４】（装置本体の構成）図２は、本例の携帯用電子機器の装置本体を、リストバンドやケーブルなどを外した状態で示す平面図、図３は、携帯用電子機器を３時の方向からみた側面図である。

【００１５】図２において、装置本体１０は、樹脂製の時計ケース１１（本体ケース）を備えており、この時計ケース１１の表面側には、現在時刻や日付に加えて、走行時や歩行時のピッチ、及び脈拍数などの脈波情報などを表示するＥＬバックライト付きの液晶表示装置１３（表示装置）が構成されている。液晶表示装置１３には、表示面の左上側に位置する第１のセグメント表示領域１３１、右上側に位置する第２のセグメント表示領域１３２、右下側に位置する第３のセグメント表示領域１３３、及び左下側に位置するドット表示領域１３４が構成されており、ドット表示領域１３４では、各種の情報をグラフィック表示可能である。

【００１６】時計ケース１１の内部には、ピッチを求めるための体動センサ９０が内蔵されており、この体動センサ９０としては、加速度センサなどを用いることができる。また、時計ケース１１の内部には、体動センサ９０による検出結果（体動信号）に基づいてピッチを求めるとともに、それを液晶表示装置１３で表示するために、また、脈波検出用センサユニット３０による検出結果（脈波信号）に基づいて脈拍数の変化などを求めるとともに、それを液晶表示装置１３で表示するために、各種の制御やデータ処理を行う制御部５が構成されている。制御部５には、計時回路も構成されているため、通常時刻、ラップタイム、スプリットタイムなども液晶表示装置１３に表示可能である。

【００１７】時計ケース１１の外周部には、時刻合わせや表示モードの切り換えなどの外部操作を行うためのボタンスイッチ１１１～１１５が構成されている。また、時計ケースの表面には、大きめのボタンスイッチ１１６、１１７が構成されている。

【００１８】携帯用電子機器１の電源は、時計ケース１１に内蔵されているボタン形の小型の電池５９であり、

ケーブル２０は、電池５９から脈波検出用センサユニット３０に電力を供給するとともに、脈波検出用センサユニット３０の検出結果を時計ケース１１の制御部５に入力している。

【００１９】携帯用電子機器１では、その機能を増やすにともなって、装置本体１０を大型化する必要があるが、装置本体１０には、腕に装着されるという制約があるため、装置本体１０を腕時計における６時及び１２時の方向に向けては拡大できない。そこで、本例では、装置本体１０には、３時及び９時の方向における長さ寸法が６時及び１２時の方向における長さ寸法よりも長い横長の時計ケース１１を用いてある。但し、リストバンド１２は、３時の方向側に偏った位置で接続しているため、リストバンド１２からみると、腕時計における９時の方向に大きな張出部分１０１を有するが、かかる大きな張出部分は３時の方向にはない。従って、横長の時計ケース１１を用いたわりには、手首を自由に曲げることができ、また、転んでも手の甲を時計ケース１１にぶつけることがない。

【００２０】時計ケース１１の内部において、電池５９に対して９時の方向には、ブザー用の偏平な圧電素子５８が配置されている。電池５９は、圧電素子５８に比較して重いため、装置本体１０の重心位置は、３時の方向に偏った位置にある。この重心が偏っている側にリストバンド１２が接続しているので、装置本体１０を腕に安定した状態で装着できる。また、電池５９と圧電素子５８とを面方向に配置してあるため、装置本体１０を薄型化できるとともに、図３に示すように、裏面部１１９に電池蓋１１８を設けることによって、ユーザーは、電池５９を簡単に交換できる。

【００２１】（装置本体の腕への装着構造）図３において、時計ケース１１の１２時の方向には、リストバンド１２の端部に取り付けられた止め軸１２１を保持するための連結部１０５が形成されている。時計ケース１１の６時の方向には、腕に巻かれたリストバンド１２が長さ方向の途中位置で折り返されるとともに、この途中位置を保持するための留め具１２２が取り付けられる受け部１０６が形成されている。

【００２２】装置本体１０の６時の方向において、裏面部１１９から受け部１０６に至る部分は、時計ケース１１と一体に成形されて裏面部１１９に対して約１１５°の角度をなす回転止め部１０８になっている。すなわち、リストバンド１２によって装置本体１０を右の手首Ｌ（腕）の上面部Ｌ１（手の甲の側）に位置するように装着したとき、時計ケース１１の裏面部１１９は、手首Ｌの上面部Ｌ１に密着する一方、回転止め部１０８は、橈骨Ｒのある側面部Ｌ２に当接する。この状態で、装置本体１０の裏面部１１９は、橈骨Ｒと尺骨Ｕを跨ぐ感じにある一方、回転止め部１０８と裏面部１１９との屈曲部分１０９から回転止め部１０８にかけては、橈骨Ｒに当接する感じになる。このように、回転止め部１０８と裏面部１１９とは、約１１５°という解剖学的に理想的な角度をなしているため、装置本体１０を矢印Ａまたは矢印Ｂの方向に回そうとしても、装置本体１０は、腕Ｌの周りを不必要にずれない。また、裏面部１１９及び回転止め部１０８によって腕の回りの片側２ヵ所で装置本体１０の回転を規制するだけであるため、腕が細くても、裏面部１１９及び回転止め部１０８は確実に腕に接するので、回転止め効果が確実に得られる一方、腕が太くても窮屈な感じがない。

【００２３】（脈波検出用センサユニットの構成）図４は、本例の脈波検出用センサユニットの断面図である。

【００２４】図４において、脈波検出用センサユニット３０は、そのケース体としてのセンサ枠３６の裏側に裏蓋３０２が被されることによって、内側に部品収納空間３００が構成されている。部品収納空間３００の内部には、回路基板３５が配置されている。回路基板３５には、ＬＥＤ３１、フォトトランジスタ３２、その他の電子部品が実装されている。脈波検出用センサユニット３０には、ブッシュ３９３によってケーブル２０の端部が固定され、ケーブル２０の各配線は、各回路基板３５のパターーン上にはんだ付けされている。ここで、脈波検出用センサユニット３０は、ケーブル２０が指の根元側から装置本体１０の側に引き出されるようにして指に取り付けられる。従って、ＬＥＤ３１及びフォトトランジスタ３２は、指の長さ方向に沿って配列されることになり、そのうち、ＬＥＤ３１は指の先端側に位置し、フォトトランジスタ３２は指の根元の方に位置する。このように配置すると、外光がフォトトランジスタ３２に届きにくいという効果がある。

【００２５】脈波検出用センサユニット３０では、センサ枠３６の上面部分（実質的な脈波信号検出部）にガラス板からなる透光板３４によって光透過窓が形成され、この透光板３４に対して、ＬＥＤ３１及びフォトトランジスタ３２は、それぞれ発光面及び受光面を透光板３４の方に向けている。このため、透光板３４の外側表面３４１（指表面との接触面／センサ面）に指表面を密着させると、ＬＥＤ３１は、指表面の側に向けて光を発するとともに、フォトトランジスタ３２は、ＬＥＤ３１が発した光のうち指の側から反射してくる光を受光可能である。ここで、透光板３４の外側表面３４１と指表面との密着性を高める目的に、透光板３４の外側表面３４１は、その周囲部分３６１から突出している構造になっている。

【００２６】本例では、ＬＥＤ３１として、ＩｎＧａＮ系（インジウムーガリウムー窒素系）の青色ＬＥＤを用いてあり、その発光スペクトルは、４５０ｎｍに発光ピークを有し、その発光波長領域は、３５０ｎｍから６００ｎｍまでの範囲にある。かかる発光特性を有するＬＥＤ３１に対応させて、本例では、フォトトランジスタ３

2として、GaAsP系（ガリウムー砒素ーリン系）のフォトトランジスタを用いてあり、その素子自身の受光波長領域は、主要感度領域が３００ｎｍから６００ｎｍまでの範囲にあって、３００ｎｍ以下にも感度領域がある。

【００２７】このように構成した脈波検出用センサユニット３０を、センサ固定用バンド４０によって指の根元に装着し、この状態で、ＬＥＤ３１から指に向けて光を照射すると、この光が血管に届いて血液中のヘモグロビンによって光の一部が吸収され、一部が反射する。指（血管）から反射してきた光は、フォトトランジスタ３２によって受光され、その受光量変化が血量変化（血液の脈波）に対応する。すなわち、血量が多いときには、反射光が弱くなる一方、血量が少なくなると、反射光が強くなるので、反射光強度の変化を検出すれば、脈拍数などを計測できる。

【００２８】本例では、発光波長領域が３５０ｎｍから６００ｎｍまでの範囲にあるＬＥＤ３１と、受光波長領域が３００ｎｍから６００ｎｍまでの範囲のフォトトランジスタ３２とを用いてあり、その重なり領域である約３００ｎｍから約６００ｎｍまでの波長領域、すなわち、約７００ｎｍ以下の波長領域における検出結果に基づいて生体情報を表示する。かかる脈波検出用センサユニット３０を用いれば、外光が指の露出部分にあたっても、外光に含まれる光のうち波長領域が７００ｎｍ以下の光は、指を導光体としてフォトトランジスタ３２（受光部）にまで到達しない。その理由は、外光に含まれる波長領域が７００ｎｍ以下の光は、指を透過しにくい傾向にあるため、外光がセンサ固定用バンド４０で覆われていない指の部分に照射されても、指を通ってフォトトランジスタ３２まで届かないからである。これに対し、８８０ｎｍ付近に発光ピークを有するＬＥＤと、シリコン系のフォトトランジスタとを用いると、その受光波長範囲は、３５０ｎｍから１２００ｎｍまでの範囲に及ぶ。この場合には、指を導光体として受光部にまで容易に届いてしまうような１μｍの波長の光による検出結果に基づいて脈波を検出することになるので、外光の変動に起因する誤検出が起こりやすい。

【００２９】また、約７００ｎｍ以下の波長領域の光を利用して、脈波情報を得ているので、血量変化に基づく脈波信号のＳ／Ｎ比が高い。その理由として、血液中のヘモグロビンは、波長が３００ｎｍから７００ｎｍまでの光に対する吸光係数が、従来の検出光である波長が８８０ｎｍの光に対する吸光係数に比して数倍～約１００倍以上大きいため、血量変化に感度よく変化するので、血量変化に基づく脈波の検出率（Ｓ／Ｎ比）が高いからと考えられる。

【００３０】（制御部の構成）図５に示すように、制御部５には、脈波検出用センサユニット３０からの入力結果に基づいて脈拍数などをもとめる脈波データ処理部５５と、体動センサ９０からの入力結果に基づいてピッチをもとめるピッチデータ処理部５６とが構成されており、ピッチデータ処理部５６及び脈波データ処理部５５は、ピッチや脈拍数などの情報を出力することによって、かかる情報を液晶表示装置１３に表示可能としている。なお、ピッチデータ処理部５６及び脈波データ処理部５５の一部は、格納されているプログラムによって動作するマイクロコンピュータで構成されており、このマイクロコンピュータの機能については、図５にブロック図で示してある。

【００３１】まず、脈波データ処理部５５では、脈波検出用センサユニット３０からケーブル２０を介して入力された信号を脈波信号増幅・変換部５５１が増幅した後、デジタル信号に変換して脈波信号記憶部５５２に出力するようになっている。脈波信号記憶部５５２は、デジタル信号に変換された脈波データを記憶しておくＲＡＭである。脈波信号演算部５５３は、脈波信号記憶部５５２に記憶されている信号を読み出してそれに周波数分析としての高速フーリエ変換（ＦＦＴ処理）を行ない、その結果を脈波成分抽出部５５４に入力するようになっている。脈波成分抽出部５５４は、脈波信号演算部５５３からの入力信号から脈波成分を抽出して脈拍数演算部５５５に出力し、この脈拍数演算部５５５は、入力された脈波の周波数成分により脈拍数を演算し、その結果を液晶表示装置１３に出力するようになっている。

【００３２】また、ピッチデータ処理部５６では、体動センサ９０から入力された信号を体動信号増幅・変換部５６１が増幅した後、デジタル信号に変換して体動信号記憶部５６２に出力するようになっている。体動信号記憶部５６２は、デジタル信号に変換された体動データを記憶しておくＲＡＭである。体動信号演算部５６３は、体動信号記憶部５６２に記憶されている信号を読み出してそれに周波数分析としての高速フーリエ変換（ＦＦＴ処理）を行ない、その結果を体動成分抽出部５６４に入力するようになっている。体動成分抽出部５６４は、体動信号演算部５６３からの入力信号から体動成分を抽出してピッチ演算部５６０に出力し、このピッチ演算部５６０は、入力された体動の周波数成分によりピッチを演算し、その結果を液晶表示装置１３に出力するようになっている。

【００３３】（ピッチ演算部の構成）ピッチ演算部５６０には、所定の周波数以上の領域でパワーが所定のレベル以上にある信号をピッチを求めるための基準波として特定する信号特定部５６５、基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第１波確認部５６６、及び基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第２波確認部５６７が構成されている。さらに、ピッチ演算部５６０には、第１波確認部５６６が基準波の周波数の１／３倍に相当する周波数を有

する高レベルの信号がないと判断したときには、基準波を体動の基本波に対する第２高調波であると判断する信号判別部５６９が構成されており、この信号判別部５６９は、第２波確認部５６７が基準波の周波数の２／３倍に相当する周波数の位置に高レベルの信号がないと判断したときにも、基準波を体動の基本波に対する第２高調波であると判断するように構成されている。

【００３４】また、信号判別部５６９は、第１波確認部５６６および第２波確認部５６７の確認結果に基づいて基準波を基本波に対する第３高調波であると判断したときでも、基準波が所定の周波数レベル以上にあると判断したときにはじめて基準波は基本波に対する第３高調波であると断定し、基準波が所定の周波数レベル以下にあると判断したときには、基準波は基本波に対する第２高調波であると断定するように構成されている。

【００３５】このように構成したピッチ演算部５６０において、体動信号演算部５６３及び体動成分抽出部５６４から出力されてくる信号は、図６（ａ）、（ｂ）に示すようなスペクトルを有しており、かかるスペクトルからピッチを求めるにあたって、ピッチ演算部５５３は、歩行時のスペクトルと走行時のスペクトルとの違いから自動的に歩行状態にあるのか走行状態にあるのかを判断し、それぞれの場合に適した演算を行うことによってピッチを求めるようになっている。

【００３６】その原理は、以下のとおりである。まず、図６（ａ）は、走行時の典型的なスペクトラムであり、体動の基本波に対応する線スペクトルＳＡ１、及び体動の基本波に対する第２高調波成分に相当する線スペクトルＳＡ２が出現し、そのうち、第２高調波成分に相当する線スペクトルＳＡ２は、基本波に対応する線スペクトルＳＡ１に比してレベルが著しく高い。走行時には、右足をステップした時と左足をステップした時に均等に上下動が出るので、体動成分の第２高調波が出現するからである。また、腕の振りの基本波は、腕の振り出し及び引き戻しを一周期とする振り子運動に相当するが、走行時には腕の振りを滑らかな振り子運動にするのが難しい分だけ、腕の振りの基本波のパワーが弱めになるからである。さらに、腕の振り出し及び引き戻しのそれぞれの瞬間に加速度がかかるため、第２高調波は、腕の振りの基本波よりは強くでるからである。

【００３７】これに対して、図６（ｂ）は、歩行時の典型的なスペクトラムであり、体動の基本波に対応する線スペクトルＳＢ１、体動の基本波に対する第２高調波成分に相当する線スペクトルＳＢ２、及び体動の基本波に対する第３高調波成分に相当する線スペクトルＳＢ３が出現する。この歩行時には、走行時ほど体動に上下動がなく、また、手振りに起因する信号成分が強く出現し、その特徴は、基本波に対応する線スペクトルＳＢ１に現れる。その結果、各線スペクトルＳＢ１，ＳＢ２，ＳＢ３の比率は一定しないものの、走行時に比較して、線スペクトルＳＢ２に対する線スペクトルＳＢ１の比が歩行時には強い。従って、体動の基本波に対応する線スペクトルＳＢ１、及び第３高調波成分に相当する線スペクトルＳＢ３は、第２高調波成分に相当する線スペクトルＳＢ２よりもレベルが高い。

【００３８】しかも、走行時の第２高調波に対応する線スペクトルＳＡ２、歩行時の第２高調波に対応する線スペクトルＳＢ２、及び歩行時の第３高調波に対応する線スペクトルＳＢ３は、通常、１００回／分以上の周波数領域に出現する。従って、１００回／分以上の周波数領域を監視し、そこに出現した信号のうち、高レベルの信号が基本波に対する第２高調波であるのか第３高調波であるのかを判断すれば、走行状態にあるのか歩行状態にあるのかを判別できる。すなわち、歩行時には、１００回／分以上の周波数領域に基本波に対する第３高調波が高レベルの信号として出現するので、この信号が第３高調波であると判断できれば、この信号の周波数に２／３倍を掛けた値から歩行時のピッチを求めることができる。逆に、走行時には、１００回／分以上の周波数領域に基本波に対する第２高調波が高レベルの信号として出現するので、この信号が第２高調波であると判断できれば、この信号の周波数から走行時のピッチを求めることができる。

【００３９】そこで、ピッチ演算部５６０は、かかるスペクトルの走行時におけるパターンと歩行時におけるパターンの違いを利用して、図７に示すフローチャートに基づく処理を行ってピッチを求める。

【００４０】まず、ステップＳＴ１では、周波数分析後のスペクトルからレベルの最も高い信号（線スペクトル）を見つける。この信号は、ピッチを求めるための基準波となるべき信号の候補である。ステップＳＴ２では、この基準波の周波数が１００回／分以上であるか否かを判断する。

【００４１】ここで、基準波の周波数が１００回／分未満であれば、ステップＳＴ３において、別の候補を見つけることになり、ステップＳＴ４において、先の信号を除く信号の中から最もレベルの高い信号を基準波として見つける。この処理において、相応の信号が見つからない場合には、ステップＳＴ５において、前回計測したピッチをそのまま今回のピッチとし、ステップＳＴ６において、この値をピッチとして確定する。

【００４２】これに対して、ステップＳＴ３、ＳＴ４での処理を行ううちに、１００回／分以上の高レベルの信号が見つかれば、この信号を基準波とし、ステップＳＴ７では、この基準波の周波数の１／３倍の周波数を有し、かつ、基準波の振幅に対して１／２倍以上の振幅を有する信号があるか否かを判断する。

【００４３】ステップＳＴ７で、基準波の周波数の１／３倍に相当する周波数を有し、かつ、基準波の振幅に対して１／２倍以上の振幅の信号がない場合には、ステッ

プＳＴ８において、基準波の周波数の２／３倍に相当する周波数を有し、かつ、基準波の振幅に対して１／２倍以上の振幅を有する信号があるか否かを判断する。

【００４４】ステップＳＴ８で、基準波の周波数の１／３倍に相当する周波数を有し、かつ、基準波の振幅に対して１／２倍以上の振幅の信号がなければ、基準波は、第２高調波成分に相当する信号と判断できるから、ステップＳＴ６において、この値をそのままピッチとして確定する。

【００４５】これに対し、ステップＳＴ７において、基準波の周波数の１／３倍に相当する周波数を有し、かつ、基準波の振幅に対して１／２倍以上の振幅の信号がある場合には、ステップＳＴ９において、この基準波の周波数が１５０回／分以上であるか否かを判断する。この１５０回／分という値は、１００回／分の１．５倍の数値であり、通常の場合、歩行中のピッチは、１００回／分～１５０回／分であり、走行中のピッチは、１５０回／分～２００回／分であることから、１５０回／分という数値を境界として歩行状態か走行状態かの再確認に用いた。従って、ステップＳＴ９において、基準波の周波数が１５０回／分以上であると判断した場合には、この基準波は、歩行時の基本波に対する第３高調波であると確認できる。それ故、基準波は、第３高調波成分に相当する信号と断定できるから、ステップＳＴ１０において、この信号の周波数を２／３倍し、この２／３倍した値を、ステップＳＴ６において、ピッチとして確定する。

【００４６】また、ステップＳＴ７において、基準波の周波数の１／３倍に相当する周波数を有し、かつ、基準波の振幅に対して１／２倍以上の振幅の信号がない場合でも、ステップＳＴ８において、基準波の周波数の２／３倍に相当する周波数を有し、かつ、基準波の振幅に対して１／２倍以上の振幅の信号があると判断した場合には、ステップＳＴ９において、この基準波の周波数が１５０回／分以上であるか否かを判断し、基準波の周波数が１５０回／分以上であると判断した場合には、この基準波は、歩行時の基本波に対する第３高調波であると確認できる。それ故、基準波は、第３高調波成分に相当する信号と断定できるから、ステップＳＴ１０において、この信号の周波数を２／３倍し、この２／３倍した値を、ステップＳＴ６において、ピッチとして確定する。

【００４７】但し、ステップＳＴ９において、この基準波の周波数が１５０回／分未満の値であれば、基準波は、第３高調波成分に相当する信号でないと判断できる。従って、この基準波の１／３倍、又は２／３倍の周波数を有する信号はあくまでノイズであり、基準波は、第２高調波成分であると判断できる。従って、ステップＳＴ６において、この値をそのままピッチとして確定する。

【００４８】このように、基準波の周波数の１／３倍に相当する周波数の位置に、基準波の振幅に対して１／２倍以上の振幅の信号がなく、かつ、基準波の周波数の２／３倍に相当する周波数の位置に、基準波の振幅に対して１／２倍以上の振幅の信号がない場合には、基準波を第２高調波であると判断する。但し、基準波の周波数の１／３倍に相当する周波数の位置に、基準波の振幅に対して１／２倍以上の振幅の信号が有り、あるいは、基準波の周波数の２／３倍に相当する周波数の位置に、基準波の振幅に対して１／２倍以上の振幅の信号が有る場合でも、それらがノイズであれば、誤って第３高調波であると判断してしまう。そこで、本例では、歩行時のピッチは、通常、１００回／分～１５０回／分の範囲にある以上、歩行時の第３高調波は、周波数が１５０回／分以上の領域に出現するはずとして、基準波の周波数が１５０回／分以上であるか否かを判断し、基準波の周波数が１５０回／分以上であると判断したときにはじめて、基準波は第３高調波であると断定する。

【００４９】（携帯用電子機器の動作）本例の携帯用電子機器１は、時計モード、ストップウォッチモード、計時と併せて脈波情報の計測を行う脈拍計モード、さらに、ピッチを計測するモードに切り換えられることから、本例の携帯用電子機器１の各モードを説明する。

【００５０】図８には、携帯用電子機器１で行われる各モード、及びそのときの液晶表示装置１３における表示内容を模式的に表してある。

【００５１】図８において、ステップＳＴ１１は、時計モードであり、第１のセグメント表示領域１３１に１９９４年１２月６日、月曜日である旨が表示され、第２のセグメント表示領域１３２には、現在時刻が午後１０時０８分５９秒である旨が表示されている。ドット表示領域１３４には、現在のモードが時計モードであるとして「ＴＩＭＥ」と表示されている。但し、後述するとおり、ドット表示領域１３４において「ＴＩＭＥ」と表示されているのは、この時計モードが選択された直後の数秒間だけである。なお、第３のセグメント表示領域１３３には、何も表示されていない。

【００５２】本例の携帯用電子機器１では、時計モードのときに２時方向にあるボタンスイッチ１１１を押すと、たとえば１時間経過した時にアラーム音を発生させることができ、このアラームの発生時刻は、任意に設定できる。また、１１時方向にあるボタンスイッチ１１３を押すと、液晶表示装置１３のＥＬバックライトが３秒間点灯し、しかる後に、自動的に消灯するようになっている。

【００５３】このモードから４時の方向にあるボタンスイッチ１１２を押すと、ランニングモード（ステップＳＴ１２）に切り換わる。このモードは、携帯用電子機器１をストップウォッチとして使用するときのモードである。ランニングモードでは、計測を開始する前（待機状態）において、第１のセグメント表示領域１３１に現在

時刻が表示され、第2のセグメント表示領域132には、「0：00′：00″：00」と表示されている。ドット表示領域134では、ランニングモードである旨の案内として「RUN」と2秒間だけ表示した後、グラフィックが切り換わる。

【0054】このモードから4時の方向にあるボタンスイッチ112を押すと、ラップタイムのリコールモード（ステップST13）に切り換わる。このモードは、携帯用電子機器1を用いて過去に計測したラップタイムやスプリットタイムを読みだすモードである。ラップタイムのリコールモードでは、第1のセグメント表示領域131に日付が表示され、第2のセグメント表示領域132には現在時刻が表示されている。ドット表示領域134には、リコールモードである旨の案内として「LAP／RECALL」と2秒間だけ表示され、次に、最新のラップ毎の脈拍数の推移が表示される。

【0055】このモードから4時の方向にあるボタンスイッチ112を押すと、脈波計測結果のリコールモード（ステップST14）に切り換わる。このモードは、過去に行ったマラソンなどのとき、携帯用電子機器1を用いて計測、記憶しておいた脈拍数の時間的変化、及び携帯用電子機器1を用いて過去に計測したピッチの時間的変化を読みだすモードである。このリコールモードでは、第1のセグメント表示領域131に日付が表示され、第2のセグメント表示領域132には現在時刻が表示されている。ドット表示領域134には、「RESULT／RECALL」と2秒間だけ表示され、次に、平均脈拍数の時間的変化を表すグラフが表示される。

【0056】このモードから、再度、4時の方向にあるボタンスイッチ112を押すと、矢印P1で示すように、時計モード（ステップST11）に戻る。また、ステップST12～ST14において、入力がない状態が10分間継続したときも、矢印P2で示すように、時計モード（ステップST11）に自動的に戻る。この時計モードに戻ったときには、第1のセグメント表示領域131に日付が表示され、第2のセグメント表示領域132に現在時刻が表示される。

【0057】本例では、時計モードになったとき、ドット表示領域134には、図9（a）に拡大して示すように、時計モードに戻ったとして「TIME」と表示されるが、この案内表示は、図9（b）に示すように、2秒後に自動的に消え、時計モードの通常状態（ステップST15）となる。この時計モードの通常状態では、ドット表示領域134に何も表示されない状態のままである。すなわち、ユーザにモードの案内を行うのに必要最小限の時間だけドット表示し、そこが消えていること自身が時計モードの通常状態である旨のモード表示とすることによって、省電力化を図ってある。

【0058】本例の携帯用電子機器1では、いずれの状態からも、コネクタ部70に対してコネクタピース80を装着すると、図8に矢印P3で示すように、ランニングモード（ステップST12）に自動的に切り換わる。このときのランニングモードは、ストップウォッチとして動作するだけでなく、ランニング中のピッチ及び脈拍数を計測できるモードである。

【0059】ピッチ計及び脈拍計としてのランニングモードにおける機能を、図10を中心に参照して説明する。

【0060】まず、図10において、ピッチ計及び脈拍計としてのランニングモードに切り換わると（ステップST31）、図11（a）に示すように、液晶表示装置の第1のセグメント表示領域131に現在時刻が表示され、第2のセグメント表示領域132には、「0：00′：00″：00」と表示され、ドット表示領域134には、「RUN」と表示される。また、第3のセグメント表示領域133でハートのマークが点滅して、ピッチ計及び脈拍計としてのランニングモードに切り換わったことを表示する。

【0061】このモードの切り換えによって、脈波データ処理部55などに電力が供給され、動作周期の設定などといった初期化処理が行われる。それから2秒後に、初期の脈拍数を計測するための脈波信号の取り込みが行われる。このとき、ドット表示領域134には、「STOP／5」との表示（ステップST32）と、「MOTION／4」との表示（ステップST33）とが2Hzで交互に行われ、5秒間、動かないようにと表示される。このとき表示される数字は、5秒間に対するカウントダウンであり、切り換わっていく。そして、時間の計測を開始するように、装置本体10表面の上側に位置するボタンスイッチ117が押されるまで待機状態となる（ステップST34）。

【0062】この待機状態では、ドット表示領域134には、図11（b）に示すように、脈波信号の原波形がグラフィック表示される。ここで表示される原波形は、最新のデータである。従って、時間の計測（マラソン）を開始する前に、脈波信号の原波形の波形やレベルを確認すれば、LED31やフォトトランジスタ32の装着状態の良否を詳しく判別できる。また、原波形の形状やレベルを確認しながらLED31やフォトトランジスタ32を調整することにより、LED31やフォトトランジスタ32の位置を最適な位置に設定することもできる。しかも、周囲の温度や湿度が計測可能な環境であるか否かを予め確認できる。さらに、かかる機能は、携帯用電子機器1の製造時において、その検査などにも利用できる。また、原波形をグラフィック表示するため、電池の消耗などによって時間軸が変動したか否かなども確認することもできる。なお、第3のセグメント表示領域132には、パルス変換から求めた初期の脈拍数「75」が表示される。

【0063】この状態から、マラソンをスタートすると

同時に、装置本体１０表面の上側に位置するボタンスイッチ１１７を押すと、経過時間の計測が開始されるとともに、ピッチ及び脈拍数の計測が行われる（ステップＳＴ３５）。

【００６４】これらの計測結果は、図１２（ａ）に示したように、まず、第２のセグメント表示領域１３２に経過時間が表示され、ドット表示領域１３４には、脈拍数の時間的変化がグラフィック表示される。このとき行うグラフィック表示は、縦軸の略中間位置を脈拍数６５として、下方から上方に延びる棒グラフによる表示である。この間、第３のセグメント表示領域１３３には、ドット表示領域１３４に表示されたグラフの縦軸の目盛りと、そのときの脈拍数が表示される。

【００６５】この状態で、脈拍数がレンジ内（脈拍数１２０から１６８までの指定範囲内）に入ったとき、図１２（ｂ）に示すように、脈拍数は、予め設定された基準脈拍数に対する差としてグラフィック表示される（ステップＳＴ３６）。このとき行うグラフィック表示は、縦軸の略中間位置を脈拍数１５０として、この値からの差に相当する分を上下（正・負方向）に延びる棒グラフによる表示である。また、ドット表示領域１３４の右側端部には、脈拍数の指定範囲を示すマークが表示される。

【００６６】この間に８時方向にあるボタンスイッチ１１４を押すと、ドット表示領域１３４にピッチの時間的変化がグラフィック表示される（ステップＳＴ３７）。このとき行うグラフィック表示は、図１２（ｃ）に示すように、縦軸の略中間位置をピッチ１７０とした折れ線グラフである。このとき、第３のセグメント表示領域１３３には、ドット表示領域１３４に表示されたグラフの縦軸の目盛り（縦軸の略中間位置がピッチ１７０である旨）と、そのときのピッチが表示される。このように、本例の携帯用電子機器１では、ドット表示領域１３４において、ピッチの時間的変化を折れ線グラフなどといった脈拍数の表示と異なる形態で表示してあるため、ランナーは、その表示形態をみるだけで現在の表示がいずれの情報を表示しているかを簡単に判別できる。

【００６７】この状態から、再び、８時方向にあるボタンスイッチ１１４を押すと、ドット表示領域１３４に脈拍数の時間的変化が表示される状態（ステップＳＴ３６）に戻る。

【００６８】また、所定の通過点を通るとき、装置本体１０表面の下側に位置するボタンスイッチ１１６を押すと、そのときのラップタイムが第１のセグメント表示領域１３１に表示される（ステップＳＴ３８）。そして、１０秒後には自動的にステップＳＴ３６に戻る。

【００６９】しかる後、ゴールに到着すると同時に装置本体１０表面の上側に位置するボタンスイッチ１１７を押すと、脈拍数、ピッチ、及び時間の計測が停止し、ドット表示領域１３４には、「ＣＯＯＬＩＮＧ／ＤＯＷＮ」と表示される（ステップＳＴ３９）。この状態から２分経過すると、ドット表示領域１３４には、ゴールした以降の脈拍数の時間的変化が脈拍回復特性としてグラフィック表示される（ステップＳＴ４０）。

【００７０】この脈拍回復特性についてのグラフィック表示は、図１３（ａ）に示すように、まず、縦軸の略中間位置を脈拍数１５０とした目盛りのままで下から上に延びる棒グラフ表示に切り換わる。そして、図１３（ｂ）に示すように、２分間の回復特性が計測される。この間、第３のセグメント表示領域１３３には、ドット表示領域１３４に表示されたグラフの縦軸の目盛りと、そのときの脈拍数が表示される。

【００７１】この状態から、８時方向にあるボタンスイッチ１１４を押すと、ドット表示領域１３４に「ＰＵＬＳＥ／ＲＥＳＵＬＴ」と１．５秒間表示された後（ステップＳＴ４１）、ドット表示領域１３４には、今回のマラソンにおける脈拍数の時間的変化が表示される（ステップＳＴ４２）。また、８時方向にあるボタンスイッチ１１４を押すと、ドット表示領域１３４に「ＰＩＴＣＨ／ＲＥＳＵＬＴ」と１．５秒間表示された後（ステップＳＴ４３）、ドット表示領域１３４には、今回のマラソンにおけるピッチの時間的変化が表示される（ステップＳＴ４４）。さらに、８時方向にあるボタンスイッチ１１４を押すと、ドット表示領域１３４に「ＣＯＯＬＩＮＧ／ＤＯＷＮ」と１．５秒間表示された後（ステップＳＴ４５）、ドット表示領域１３４にゴールした以降の脈拍数の時間的変化が脈拍回復特性としてグラフィック表示される状態（ステップＳＴ４０）に戻る。

【００７２】なお、ゴールした以降、装置本体１０表面の下側に位置するボタンスイッチ１１６を押すと、ドット表示領域１３４には、今回の結果を記憶しておくか否かの案内「ＰＲＯＴＥＣＴ／ＭＥＭＯ？Ｙ」が表示され（ステップＳＴ４６）、装置本体１０表面の上側に位置するボタンスイッチ１１７を押して「ＹＥＳ」と返答すると、ドット表示領域１３４には、結果を記憶処理中であるとして「ＭＥＭＯＲＹ」と表示され（ステップＳＴ４７）、２秒後には、初期状態（ステップＳＴ３１）に戻る。

【００７３】このピッチ計及び脈拍計としての計測が終了した後に、４時の方向にあるボタンスイッチ１１２を押すと、図８に示したように、ラップタイムのリコールモード（ステップＳＴ１３）に切り換わる。このモードから、４時の方向にあるボタンスイッチ１１２を押すと、脈波計測結果のリコールモード（ステップＳＴ１４）に切り換わる。このモードにおいても、ドット表示領域１３４には、ピッチ及び脈拍数の時間的変化をグラフィック表示することができる。この状態から、４時の方向にあるボタンスイッチ１１２を押すと、時計モード（ステップＳＴ１１）に戻る。

【００７４】このモードに戻したときも、第１のセグメント表示領域１３３に日付が表示され、第２のセグメン

ト表示領域１３２に現在時刻が表示される。また、ドット表示領域１３４には、時計モードに戻ったとして「ＴＩＭＥ」との案内表示が行われるが、この表示は、矢印Ｐ４で示すように、２秒後に自動的に消え、時計モードの通常状態（ステップＳＴ１５）となる。

【００７５】（実施例の主な効果）以上のように、体動信号を周波数分析した後のスペクトラムにおいて、１００回／分以上の周波数領域には、走行時には基本波に対する第２高調波が高レベルの信号として出現し、歩行時には基本波に対する第３高調波が高レベルの信号として出現することを見いだし、この知見に基づいて、本例の携帯用電子機器１では、この高レベルの信号が走行時の基本波に対する第２高調波か、あるいは、歩行時の基本波に対する第３高調波であるかを求め、基準波が第２高調波としての信号であると判断したときにその周波数からピッチを求め、基準波が第３高調波としての信号であると判断したときにその周波数の２／３倍に相当する値からピッチを求める。従って、走行時及び歩行時のいずれの場合でも、簡単で迅速な処理によってピッチを正確に求めることができるとともに、走る時と歩く時とでモードを切り換えるための外部操作が不要であるため、使い勝手がよい。

【００７６】また、本例では、基準波の周波数の１／３倍または２／３倍に相当する周波数の位置に、基準波の振幅に対して１／２倍以上の振幅の信号が有る場合でも、基準波の周波数が１５０回／分以上であると判断したときにはじめて、基準波は第３高調波であると断定する。このように、ダブルチェックしながら第２高調波であるか第３高調波であるかを判断するので、ノイズなどに起因する誤った判断を防止できる。

【００７７】

【発明の効果】以上のように、本発明に係るピッチ計では、体動信号を周波数分析した後のスペクトラムにおいて、たとえば、１００回／分以上の周波数領域に出現する高いレベルが走行時の基本波に対する第２高調波か、あるいは、歩行時の基本波に対する第３高調波であるかを求め、その結果から、ピッチを自動的に求めることに特徴を有する。従って、本発明によれば、走行時及び歩行時のいずれの場合でも、ピッチを正確にかつ迅速に求めることができるとともに、走る時と歩く時とでモードを切り換えるための外部操作が不要であるため、使い勝手がよい。

【００７８】さらに、基準波の周波数の１／３倍または２／３倍に相当する周波数の位置に、高レベルの信号が有る場合でも、基準波の周波数が所定の周波数レベル以上であると判断したときにはじめて基準波は第３高調波であると断定するように構成した場合には、ダブルチェックしながら第２高調波であるか第３高調波であるかを判断するので、ノイズなどに起因する誤った判断を防止できる。

【図面の簡単な説明】

【図１】本発明の一実施例に係る携帯用電子機器の全体構成、及び使用状態を示す説明図である。

【図２】図１に示す携帯用電子機器の装置本体の平面図である。

【図３】図１に示す携帯用電子機器の装置本体を腕時計の３時の方向からみたときの説明図である。

【図４】図１に示す携帯用電子機器に用いた脈波検出用センサユニットの断面図である。

【図５】図１に示す携帯用電子機器の制御部（脈波データ処理部及びピッチデータ処理部）の機能の一部を示すブロック図である。

【図６】図１に示す携帯用電子機器において、ピッチを求める原理を説明するための説明図であって、（ａ）は、走行時に得られた体動信号に周波数分析を行って得られたスペクトラム、（ｂ）は、歩行時に得られた体動信号に周波数分析を行って得られたスペクトラムである。

【図７】図５に示すピッチデータ処理部のピッチ演算部における動作を示すフローチャートである。

【図８】図１に示す携帯用電子機器の各モードを示す説明図である。

【図９】（ａ）は、図８に示すモードのうち時計モードが選択されたときの案内表示を示す説明図、（ｂ）は、この案内表示が消えた状態を示す説明図である。

【図１０】図１に示す携帯用電子機器において、ピッチ計及び脈拍計としてのランニングモードにおける機能を説明するための説明図である。

【図１１】（ａ）は、図１０に示すピッチ計及び脈拍計としてのランニングモードに切り換わったとの表示の内容を示す説明図、（ｂ）は、このモードにおいて計測開始する前の表示の内容を示す説明図である。

【図１２】（ａ）は、図１１に示すピッチ計及び脈拍計としてのランニングモードにおいて、脈拍数の計測を開始した以降、脈拍数が所定のレンジ内に到達する以前の表示形態を示す説明図、（ｂ）は、脈拍数が所定のレンジ内に到達した以降の表示形態を示す説明図、（ｃ）は、ピッチの時間的変化を示すときの表示形態を示す説明図である。

【図１３】（ａ）は、図１に示す携帯用電子機器において、脈拍数の計測を停止するようにとの操作があった以降、脈拍数が所定のレンジ内にあるときの表示形態を示す説明図、（ｂ）は、脈拍数が所定のレンジ内から外れたときの表示形態を示す説明図である。

【図１４】（ａ）は、従来のピッチ計における体動信号をパルス変換した後の波形図、（ｂ）は、従来のピッチ計において、パルスをカウントする際のマスクを説明するための波形図である。

【符号の説明】

１・・・携帯用電子機器（ピッチ計）

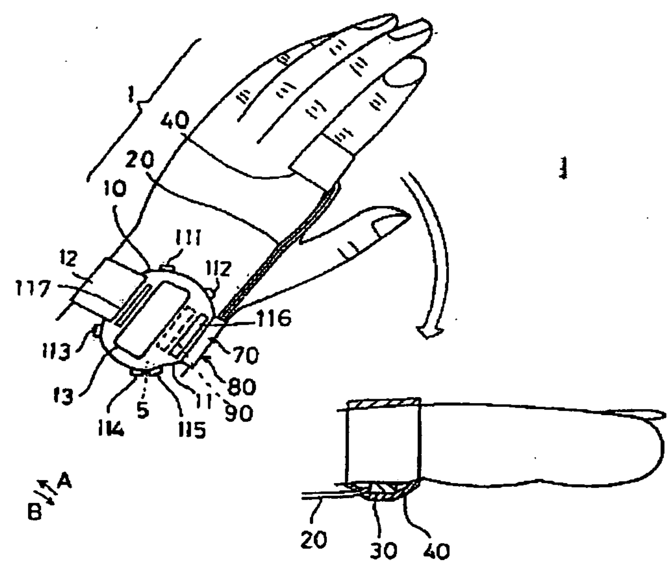
19

５・・・制御部
１０・・・装置本体
１２・・・リストバンド
１３・・・液晶表示装置
３０・・・脈波検出用センサユニット
３１・・・ＬＥＤ

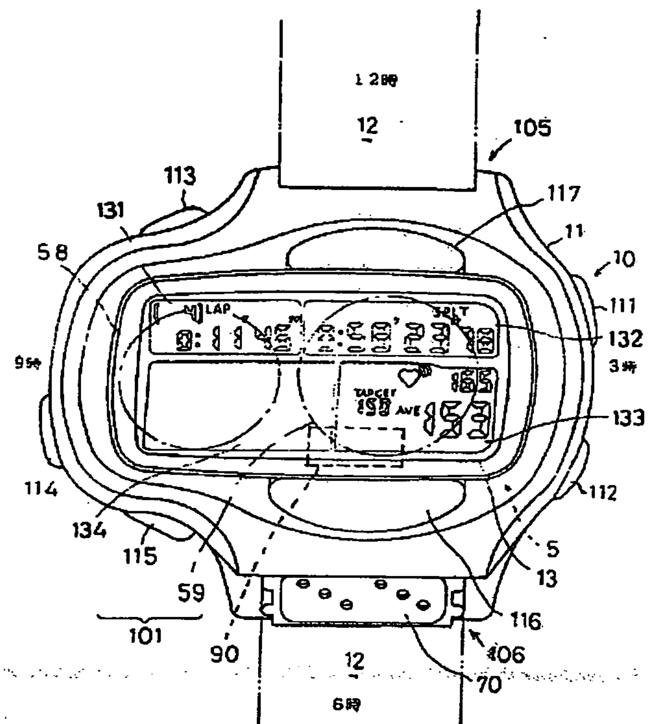
20

３２・・・フォトトランジスタ
５５・・・脈波データ処理部
５６・・・ピッチデータ処理部
９０・・・体動センサ
５６０・・・ピッチ演算部

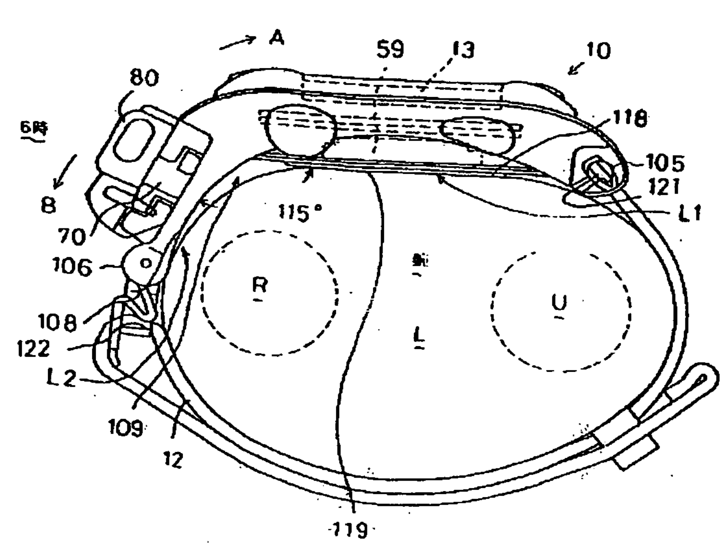
【図１】



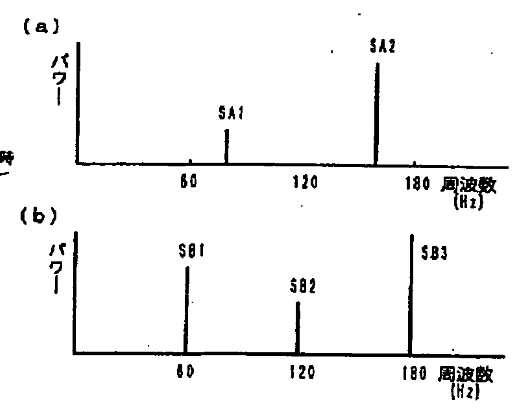
【図２】



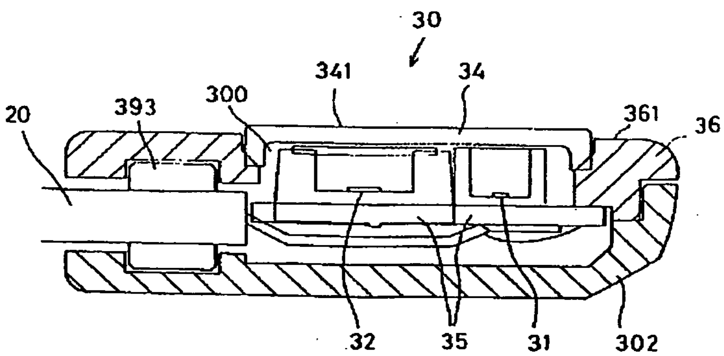
【図３】



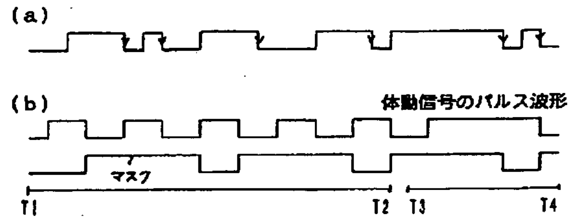
【図６】



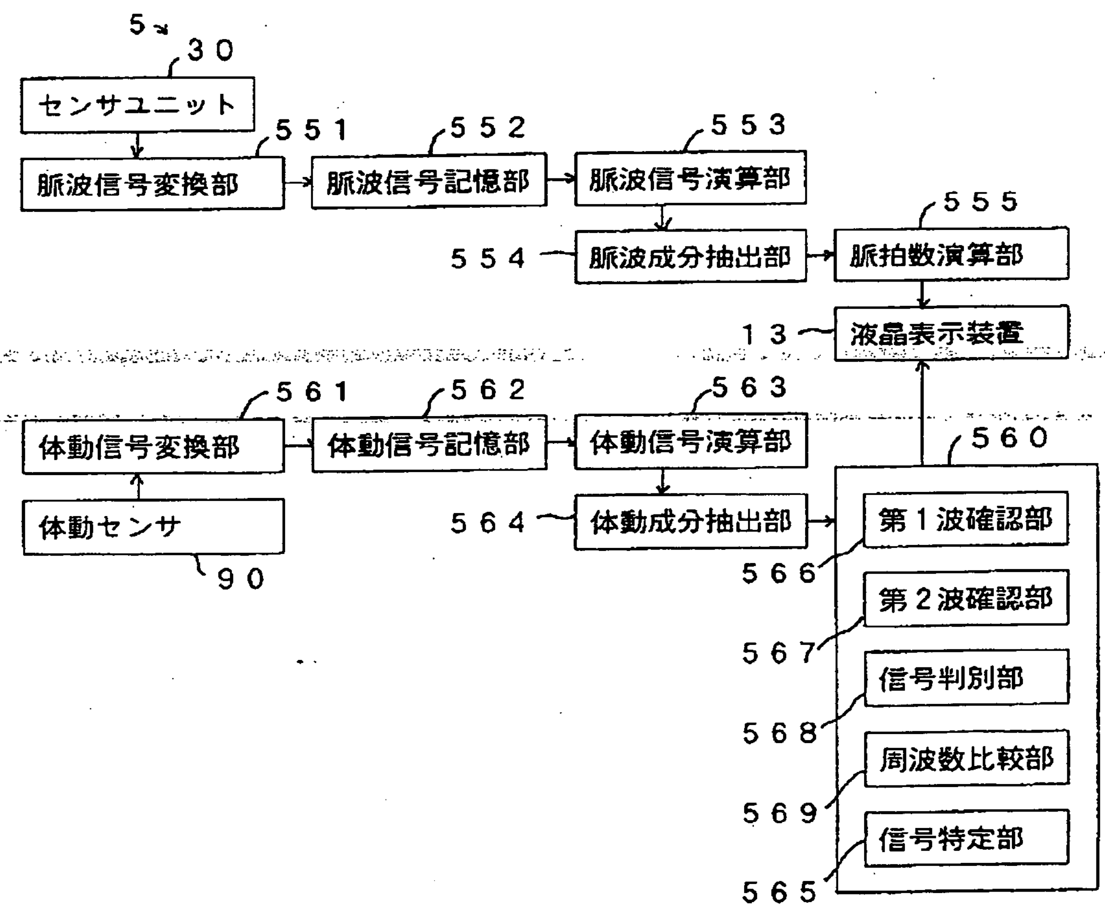
【図4】


30
341
34
300
393
20
361
36
32
35
31
302

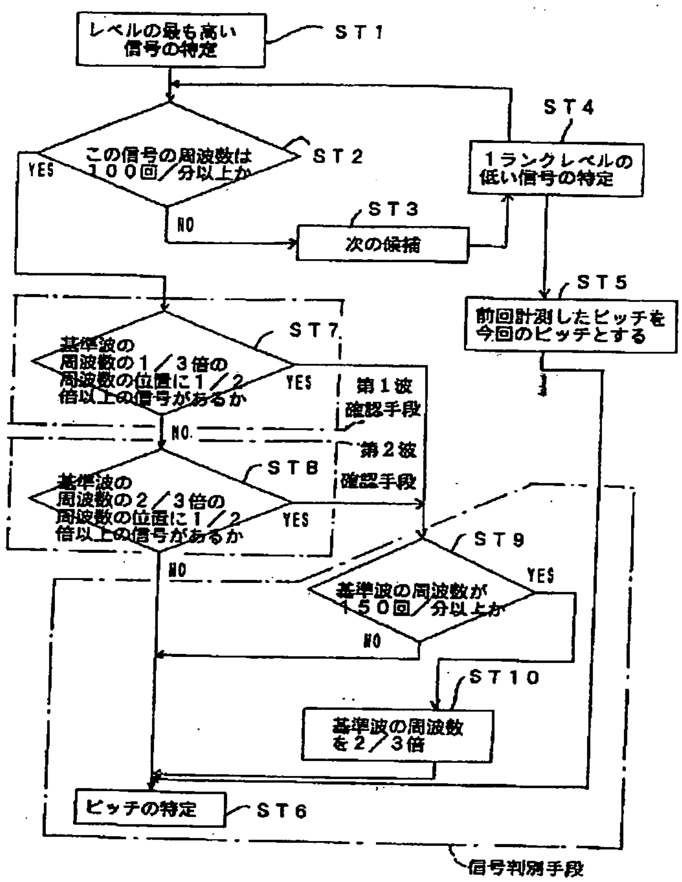
【図14】


(a)
(b)
体動信号のパルス波形
マスク
T1
T2
T3
T4

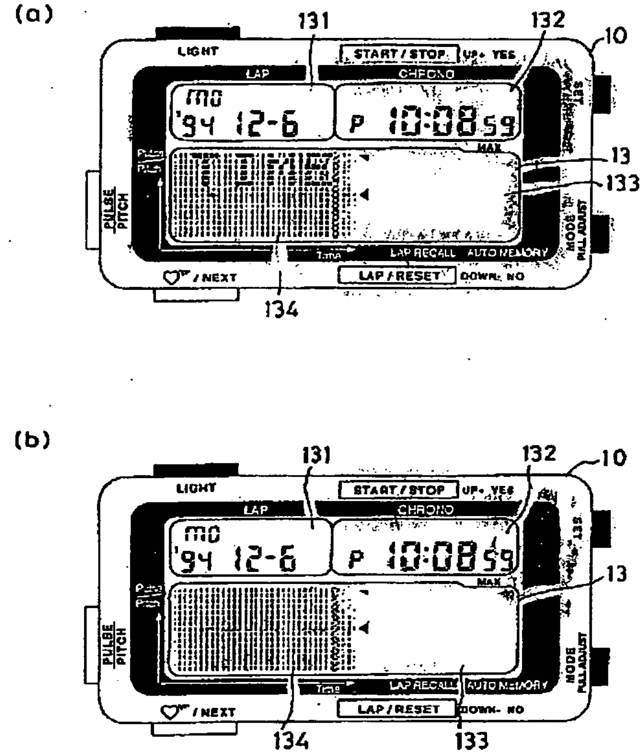
【図5】


5
30
センサユニット
551
脈波信号変換部
552
脈波信号記憶部
553
脈波信号演算部
554
脈波成分抽出部
555
脈拍数演算部
13
液晶表示装置
561
体動信号変換部
562
体動信号記憶部
563
体動信号演算部
体動センサ
90
564
体動成分抽出部
560
第1波確認部
566
第2波確認部
567
信号判別部
568
周波数比較部
569
信号特定部
565

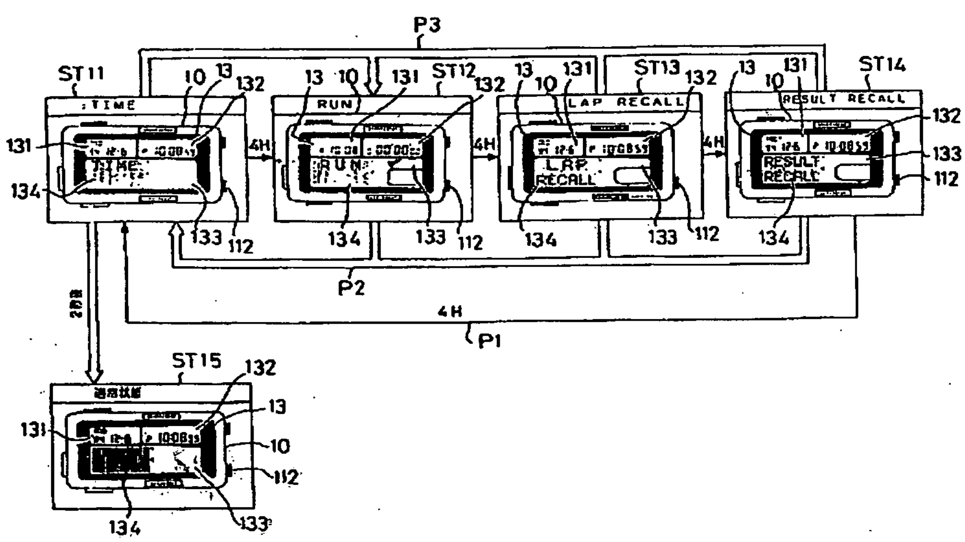
【図7】


レベルの最も高い信号の特定
ST1
この信号の周波数は１００回／分以上か
ST2
YES
NO
次の候補
ST3
１ランクレベルの低い信号の特定
ST4
前回計測したピッチを今回のピッチとする
ST5
基準波の周波数の１／３倍の周波数の位置に１／２倍以上の信号があるか
ST7
YES
NO
第１波確認手段
基準波の周波数の２／３倍の周波数の位置に１／２倍以上の信号があるか
ST8
YES
NO
第２波確認手段
基準波の周波数が１５０回／分以上か
ST9
YES
NO
基準波の周波数を２／３倍
ST10
ピッチの特定
ST6
信号判別手段

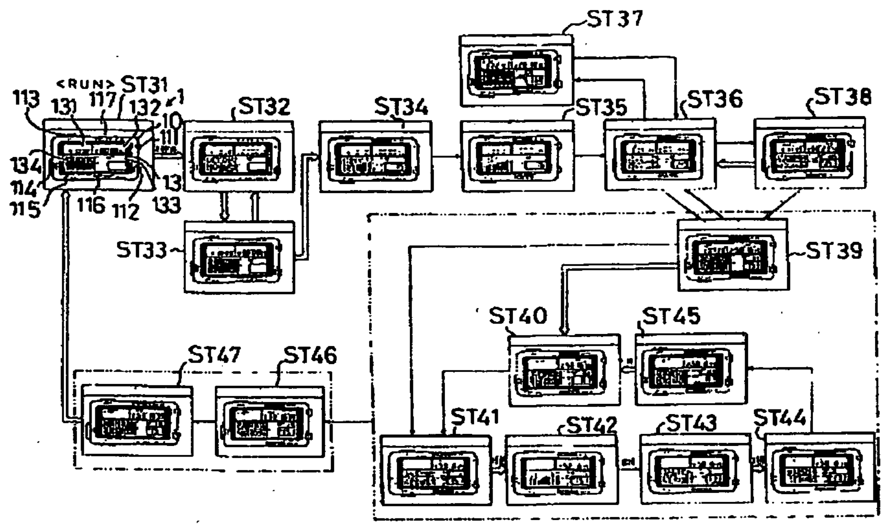
【図9】


(a)
(b)
131
132
10
13
133
134
LIGHT
START / STOP
LAP
CHRONO
LAP / RESET
PULSE PITCH
MODE
LAP RECALL
AUTO MEMORY
/ NEXT

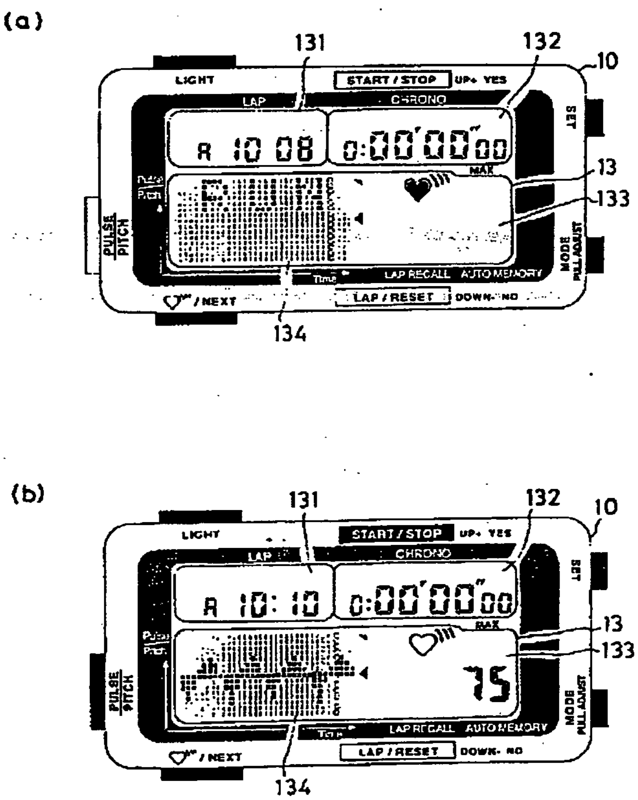
【図8】


P3
ST11
ST12
ST13
ST14
ST15
TIME
RUN
LAP RECALL
RESULT RECALL
4H
P2
P1
10
13
131
132
133
134
112

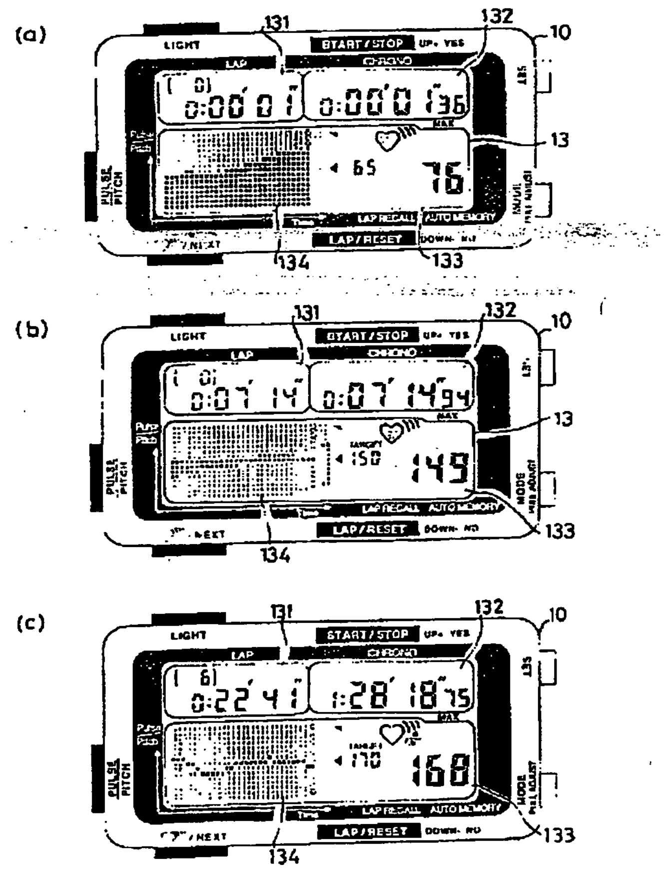
【図１０】


<RUN>
ST31
ST32
ST33
ST34
ST35
ST36
ST37
ST38
ST39
ST40
ST41
ST42
ST43
ST44
ST45
ST46
ST47
113
131
117
132
1
10
111
134
114
115
116
112
133
13

【図１１】

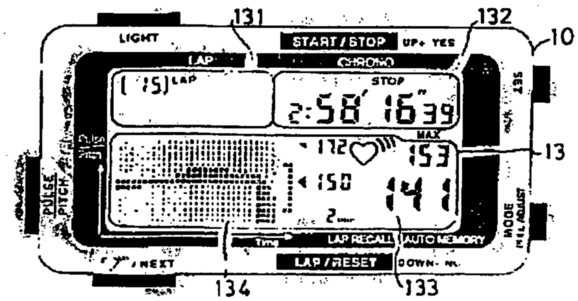

(a)
(b)
131
132
10
13
133
134
LIGHT
START / STOP
UP+ YES
LAP
CHRONO
SET
MAX
PULSE
PITCH
Pulse
Pitch
Time
LAP RECALL
AUTO MEMORY
MODE
PULL ADJUST
/ NEXT
LAP / RESET
DOWN- NO
A 10 08
A 10:10
0:00'00"00
75

【図１２】

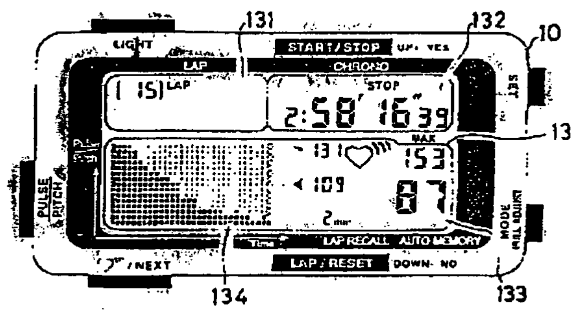

(a)
(b)
(c)
131
132
10
13
133
134
LIGHT
START / STOP
UP+ YES
LAP
CHRONO
MAX
PULSE
PITCH
Time
LAP RECALL
AUTO MEMORY
MODE
LAP / RESET
/ NEXT
0:00'01"
0:00'01"36
65
76
0:07'14"
0:07'14"94
150
149
0:22'41"
1:28'18"75
170
168

【図13】

(a)



(b)



【公報種別】特許法第１７条の２の規定による補正の掲載
【部門区分】第６部門第３区分
【発行日】平成１４年2月２８日（２００２．２．２８）

【公開番号】特開平９－１１４９５５
【公開日】平成９年５月２日（１９９７．５．２）
【年通号数】公開特許公報９－１１５０
【出願番号】特願平７－２７０３９４
【国際特許分類第７版】
G06M 7/00
A61B 5/0245
G04G 1/00 315
【ＦＩ】
G06M 7/00
G04G 1/00 315 D
A61B 5/02 310 F
320 B
322

【手続補正書】
【提出日】平成１３年９月３日（２００１．９．３）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】００２２
【補正方法】変更
【補正内容】
【００２２】装置本体１０の６時の方向において、裏面部１１９から受け部１０６に至る部分は、時計ケース１１と一体に成形されて裏面部１１９に対して約１１５°の角度をなす回転止め部１０８になっている。すなわち、リストバンド１２によって装置本体１０を左の手首Ｌ（腕）の上面部Ｌ１（手の甲の側）に位置するように装着したとき、時計ケース１１の裏面部１１９は、手首Ｌの上面部Ｌ１に密着する一方、回転止め部１０８は、橈骨Ｒのある側面部Ｌ２に当接する。この状態で、装置本体１０の裏面部１１９は、橈骨Ｒと尺骨Ｕを跨ぐ感じにある一方、回転止め部１０８と裏面部１１９との屈曲部分１０９から回転止め部１０８にかけては、橈骨Ｒに当接する感じになる。このように、回転止め部１０８と裏面部１１９とは、約１１５°という解剖学的に理想的な角度をなしているため、装置本体１０を矢印Ａまたは矢印Ｂの方向に回そうとしても、装置本体１０は、腕Ｌの周りを不必要にずれない。また、裏面部１１９及び回転止め部１０８によって腕の回りの片側２ヵ所で装置本体１０の回転を規制するだけであるため、腕が細くても、裏面部１１９及び回転止め部１０８は確実に腕に接するので、回転止め効果が確実に得られる一方、腕が太くても窮屈な感じがない。
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】００３３
【補正方法】変更
【補正内容】
【００３３】（ピッチ演算部の構成）
ピッチ演算部５６０には、所定の周波数以上の領域でパワーが所定のレベル以上にある信号をピッチを求めるための基準波として特定する信号特定部５６５、基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第１波確認部５６６、及び基準波の周波数の２／３倍に相当する周波数を有する高レベルの信号があるか否かを判断する第２波確認部５６７が構成されている。さらに、ピッチ演算部５６０には、第１波確認部５６６が基準波の周波数の１／３倍に相当する周波数を有する高レベルの信号がないと判断したときには、基準波を体動の基本波に対する第２高調波であると判断する信号判別部５６８が構成されており、この信号判別部５６８は、第２波確認部５６７が基準波の周波数の２／３倍に相当する周波数の位置に高レベルの信号がないと判断したときにも、基準波を体動の基本波に対する第２高調波であると判断するように構成されている。
【手続補正３】
【補正対象書類名】明細書
【補正対象項目名】００３４
【補正方法】変更
【補正内容】
【００３４】また、信号判別部５６８は、第１波確認部５６６および第２波確認部５６７の確認結果に基づいて基準波を基本波に対する第３高調波であると判断したときでも、基準波が所定の周波数レベル以上にあると判断

1

したときにはじめて基準波は基本波に対する第３高調波であると断定し、基準波が所定の周波数レベル以下にあると判断したときには、基準波は基本波に対する第２高調波であると断定するように構成されている。

【手続補正４】
【補正対象書類名】明細書
【補正対象項目名】００３５
【補正方法】変更
【補正内容】
【００３５】このように構成したピッチ演算部５６０において、体動信号演算部５６３及び体動成分抽出部５６４から出力されてくる信号は、図６（ａ）、（ｂ）に示すようなスペクトルを有しており、かかるスペクトルからピッチを求めるにあたって、ピッチ演算部５６０は、歩行時のスペクトルと走行時のスペクトルとの違いから自動的に歩行状態にあるのか走行状態にあるのかを判断し、それぞれの場合に適した演算を行うことによってピッチを求めるようになっている。

【手続補正５】
【補正対象書類名】明細書
【補正対象項目名】００３６
【補正方法】変更
【補正内容】
【００３６】その原理は、以下のとおりである。まず、図６（ａ）は、走行時の典型的なスペクトルであり、体動の基本波に対応する線スペクトルＳＡ１、及び体動の基本波に対する第２高調波成分に相当する線スペクトルＳＡ２が出現し、そのうち、第２高調波成分に相当する線スペクトルＳＡ２は、基本波に対応する線スペクトルＳＡ１に比してレベルが著しく高い。走行時には、右足をステップした時と左足をステップした時に均等に上下動が出るので、体動成分の第２高調波が出現するからである。また、腕の振りの基本波は、腕の振り出し及び引き戻しを一周期とする振り子運動に相当するが、走行時には腕の振りを滑らかな振り子運動にするのが難しい分だけ、腕の振りの基本波のパワーが弱めになるからである。さらに、腕の振り出し及び引き戻しのそれぞれの瞬間に加速度がかかるため、第２高調波は、腕の振りの基本波よりは強くでるからである。

【手続補正６】
【補正対象書類名】明細書
【補正対象項目名】００３７
【補正方法】変更
【補正内容】
【００３７】これに対して、図６（ｂ）は、歩行時の典型的なスペクトルであり、体動の基本波に対応する線スペクトルＳＢ１、体動の基本波に対する第２高調波成分に相当する線スペクトルＳＢ２、及び体動の基本波に対する第３高調波成分に相当する線スペクトルＳＢ３が出現する。この歩行時には、走行時ほど体動に上下動がなく、また、手振りに起因する信号成分が強く出現し、その特徴は、基本波に対応する線スペクトルＳＢ１に現れる。その結果、各線スペクトルＳＢ１，ＳＢ２，ＳＢ３の比率は一定しないものの、走行時に比較して、線スペクトルＳＢ２に対する線スペクトルＳＢ１の比が歩行時には強い。従って、体動の基本波に対応する線スペクトルＳＢ１、及び第３高調波成分に相当する線スペクトルＳＢ３は、第２高調波成分に相当する線スペクトルＳＢ２よりもレベルが高い。

2

【手続補正７】
【補正対象書類名】明細書
【補正対象項目名】００４４
【補正方法】変更
【補正内容】
【００４４】ステップＳＴ８で、基準波の周波数の２／３倍に相当する周波数を有し、かつ、基準波の振幅に対して１／２倍以上の振幅の信号がなければ、基準波は、第２高調波成分に相当する信号と判断できるから、ステップＳＴ６において、この値をそのままピッチとして確定する。

【手続補正８】
【補正対象書類名】明細書
【補正対象項目名】００６２
【補正方法】変更
【補正内容】
【００６２】この待機状態では、ドット表示領域１３４には、図１１（ｂ）に示すように、脈波信号の原波形がグラフィック表示される。ここで表示される原波形は、最新のデータである。従って、時間の計測（マラソン）を開始する前に、脈波信号の原波形の波形やレベルを確認すれば、ＬＥＤ３１やフォトトランジスタ３２の装着状態の良否を詳しく判別できる。また、原波形の形状やレベルを確認しながらＬＥＤ３１やフォトトランジスタ３２の位置を最適な位置に設定することもできる。しかも、周囲の温度や湿度が計測可能な環境であるか否かを予め確認できる。さらに、かかる機能は、携帯用電子機器１の製造時において、その検査などにも利用できる。また、原波形をグラフィック表示するため、電池の消耗などによって時間軸が変動したか否かなども確認することもできる。なお、第３のセグメント表示領域１３２には、パルス変換から求めた初期の脈拍数「７５」が表示される。

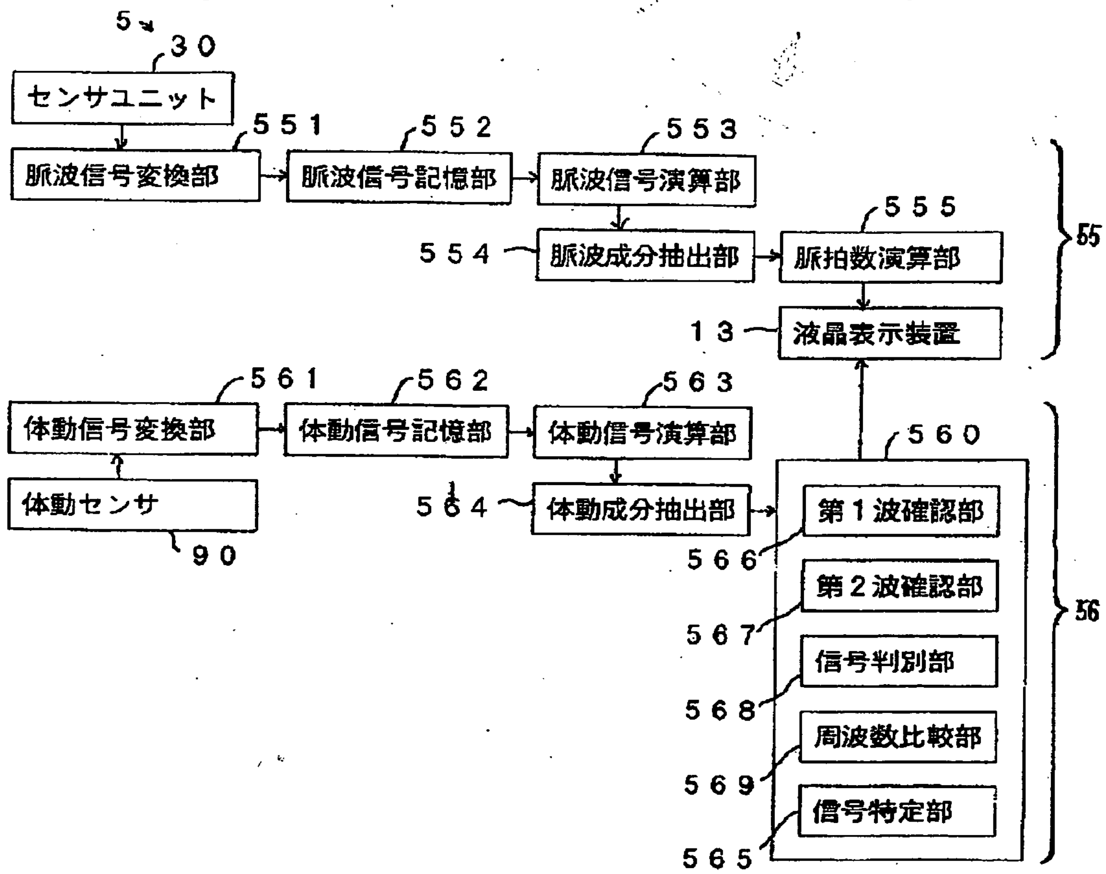
【手続補正９】
【補正対象書類名】明細書
【補正対象項目名】００７５
【補正方法】変更
【補正内容】
【００７５】（実施例の主な効果）
以上のように、体動信号を周波数分析した後のスペクトルにおいて、１００回／分以上の周波数領域には、走行

時には基本波に対する第２高調波が高レベルの信号として出現し、歩行時には基本波に対する第３高調波が高レベルの信号として出現することを見いだし、この知見に基づいて、本例の携帯用電子機器１では、この高レベルの信号が走行時の基本波に対する第２高調波か、あるいは、歩行時の基本波に対する第３高調波であるかを求め、基準波が第２高調波としての信号であると判断したときにその周波数からピッチを求め、基準波が第３高調波としての信号であると判断したときにその周波数の２／３倍に相当する値からピッチを求める。従って、走行時及び歩行時のいずれの場合でも、簡単で迅速な処理によってピッチを正確に求めることができるとともに、走る時と歩く時とでモードを切り換えるための外部操作が不要であるため、使い勝手がよい。

【手続補正１０】
【補正対象書類名】明細書
【補正対象項目名】００７７
【補正方法】変更
【補正内容】
【００７７】
【発明の効果】以上のように、本発明に係るピッチ計では、体動信号を周波数分析した後のスペクトルにおいて、たとえば、１００回／分以上の周波数領域に出現する高いレベルが走行時の基本波に対する第２高調波か、あるいは、歩行時の基本波に対する第３高調波であるかを求め、その結果から、ピッチを自動的に求めることに特徴を有する。従って、本発明によれば、走行時及び歩行時のいずれの場合でも、ピッチを正確にかつ迅速に求めることができるとともに、走る時と歩く時とでモードを切り換えるための外部操作が不要であるため、使い勝手がよい。

【手続補正１１】
【補正対象書類名】明細書
【補正対象項目名】図面の簡単な説明
【補正方法】変更
【補正内容】
【図面の簡単な説明】
【図１】本発明の一実施例に係る携帯用電子機器の全体構成、及び使用状態を示す説明図である。
【図２】図１に示す携帯用電子機器の装置本体の平面図である。
【図３】図１に示す携帯用電子機器の装置本体を腕時計の３時の方向からみたときの説明図である。
【図４】図１に示す携帯用電子機器に用いた脈波検出用センサユニットの断面図である。

【図５】図１に示す携帯用電子機器の制御部（脈波データ処理部及びピッチデータ処理部）の機能の一部を示すブロック図である。
【図６】図１に示す携帯用電子機器において、ピッチを求める原理を説明するための説明図であって、（ａ）は、走行時に得られた体動信号に周波数分析を行って得られたスペクトル、（ｂ）は、歩行時に得られた体動信号に周波数分析を行って得られたスペクトルである。
【図７】図５に示すピッチデータ処理部のピッチ演算部における動作を示すフローチャートである。
【図８】図１に示す携帯用電子機器の各モードを示す説明図である。
【図９】（ａ）は、図８に示すモードのうち時計モードが選択されたときの案内表示を示す説明図、（ｂ）は、この案内表示が消えた状態を示す説明図である。
【図１０】図１に示す携帯用電子機器において、ピッチ計及び脈拍計としてのランニングモードにおける機能を説明するための説明図である。
【図１１】（ａ）は、図１０に示すピッチ計及び脈拍計としてのランニングモードに切り換わったとの表示の内容を示す説明図、（ｂ）は、このモードにおいて計測を開始する前の表示の内容を示す説明図である。
【図１２】（ａ）は、図１１に示すピッチ計及び脈拍計としてのランニングモードにおいて、脈拍数の計測を開始した以降、脈拍数が所定のレンジ内に到達する以前の表示形態を示す説明図、（ｂ）は、脈拍数が所定のレンジ内に到達した以降の表示形態を示す説明図、（ｃ）は、ピッチの時間的変化を示すときの表示形態を示す説明図である。
【図１３】（ａ）は、図１に示す携帯用電子機器において、脈拍数の計測を停止するようにとの操作があった以降、脈拍数が所定のレンジ内にあるときの表示形態を示す説明図、（ｂ）は、脈拍数が所定のレンジ内から外れたときの表示形態を示す説明図である。
【図１４】（ａ）は、従来のピッチ計における体動信号をパルス変換した後の波形図、（ｂ）は、従来のピッチ計において、パルスをカウントする際のマスクを説明するための波形図である。
【手続補正１２】
【補正対象書類名】図面
【補正対象項目名】図５
【補正方法】変更
【補正内容】
【図５】



5
30
センサユニット
551
脈波信号変換部
552
脈波信号記憶部
553
脈波信号演算部
554
脈波成分抽出部
555
脈拍数演算部
13
液晶表示装置
55
561
体動信号変換部
562
体動信号記憶部
563
体動信号演算部
体動センサ
90
564
体動成分抽出部
560
第1波確認部
566
第2波確認部
567
信号判別部
568
周波数比較部
569
信号特定部
565
56

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 09-114955
(43)Date of publication of application : 02.05.1997

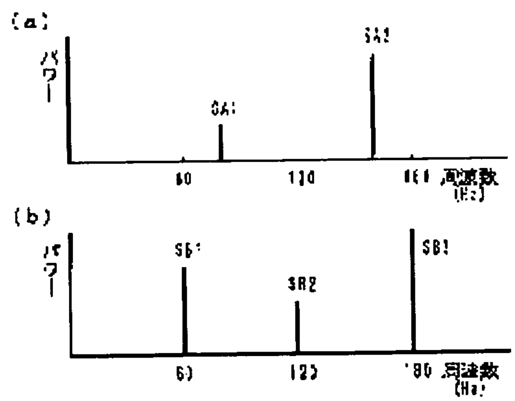
(51)Int.Cl. G06M 7/00
A61B 5/0245
G04G 1/00

(21)Application number : 07-270394
(22)Date of filing : 18.10.1995

(71)Applicant : SEIKO EPSON CORP
SEIKO INSTR INC
(72)Inventor : HAYAKAWA MOTOMU
NAKAMURA CHIAKI

(54) PITCH METER

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a pitch meter capable of measuring pitch at either time of running and walking and without necessitating any external operation for switching the setting of conditions between running and walking.
SOLUTION: In the pitch arithmetic part of a portable electronic equipment, at the spectrum after the frequency of a body action signal is analyzed, line spectrums SA2 and SB3 with high level appearing in the area of ≥100times/sec are second higher harmonic waves corresponding to a basic wave at the time of running or third higher harmonic waves corresponding to a basic wave at the time of walking. Then, it is found whether the line spectrums SA2 and SB3 are the second higher harmonic waves or the third higher harmonic waves, and when the signal as the second higher harmonic wave is judged, the pitch is found from its frequency but when the signal as the third higher harmonic wave is judged, the pitch is found from value corresponding to that 2/3-fold frequency.



LEGAL STATUS

[Date of request for examination] 03.09.2001
[Date of sending the examiner's decision of rejection] 02.03.2004
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision

of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

Laid-open Patent Application No. JP09-114955,A

Japan Patent Office provides this translation by using a computer.

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] In the analysis result of the body motion sensor which detects a body motion, a frequency-analysis means to carry out frequency analysis to the detection result of this body motion sensor, and this frequency-analysis means While power specifies the signal which exists more than predetermined level as a criteria wave for asking for a pitch in the field more than a predetermined frequency It judges whether this criteria wave is the 2nd higher harmonic over the fundamental wave of a body motion, or it is the 3rd higher harmonic. Pitchometer characterized by having a pitch operation means to ask for a pitch from the frequency when it judges that this criteria wave is the 2nd higher harmonic wave, and to calculate a pitch from the value which corresponds by 2/3 time the frequency when it judges that this criteria wave is the 3rd higher harmonic wave.

[Claim 2] A 1st wave check means to judge whether said pitch operation means has the signal of the high level which has the frequency which corresponds by 1/3 time the frequency of said criteria wave in claim 1, Pitchometer characterized by having a signal distinction means to judge said criteria wave to be the 2nd higher harmonic wave over said fundamental wave when it judges that there is no signal of the high level which has the frequency on which this 1st wave check means corresponds by 1/3 time the frequency of said criteria wave.

[Claim 3] A 2nd wave check means to judge whether said pitch operation means has the signal of the high level which has the frequency which corresponds by 2/3 time the frequency of said criteria wave in claim 1, Pitchometer characterized by having a signal distinction means to judge said criteria wave to be the 2nd higher harmonic wave over said fundamental wave when it judges that there is no signal of the high level which has the frequency on which this 2nd wave check means corresponds by 2/3 time the frequency of said criteria wave.

[Claim 4] It has a 2nd wave check means to judge whether said pitch operation means has the signal of the high level which has the frequency which corresponds by 2/3 time the frequency of said criteria wave in claim 2. It is judged that said signal distinction means does not have the signal of the high level which has the frequency on which said 1st wave check means corresponds by 1/3 time the frequency of said criteria wave. And pitchometer characterized by being constituted so that said criteria wave may be judged to be the 2nd higher harmonic wave over said fundamental wave, when it judges that there is no signal of the high level which has the frequency on which said 2nd wave check means corresponds by 2/3 time the frequency of said criteria wave.

[Claim 5] In claim 2 thru/or one term of 4 said signal distinction means Based on the check result of whether there is any signal of the high level which has a frequency equivalent to the predetermined multiple of the frequency of said criteria wave, said criteria wave is judged to be the 3rd higher harmonic over said fundamental wave. And it is the pitchometer characterized by being constituted so that it may conclude that said criteria wave is the 3rd higher harmonic wave over said fundamental wave when said criteria wave judges that it is more than predetermined frequency level.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the technique for asking for a pitch in more detail about pitchometer from the body motion signal detected at the time of transit or a walk.
[0002]
[Description of the Prior Art] In pitchometer, by the acceleration sensor built in it, a body motion signal is detected and it is asking for the pitch from this body motion signal. For example, if pulse conversion is carried out after amplifying a body motion signal, the pulse shape shown in drawing 14 (a) will be obtained. Thus, an error is large although there is the approach of setting up a predetermined threshold from pulse separation being irregular according to a run state, and counting a pulse in the obtained pulse shape. Then, as shown in drawing 14 (b), in case a pulse is counted, by setting up mask time amount, a pulse is counted per two shots and the approach of raising detection precision is used. For example, if a pulse period counts the pitch at the time of transit as a pulse which is 0.8 seconds - 0.6 seconds by usually setting mask time amount as 0.5 seconds a part for /-, and 200 times 150 times since it is a part for /and is 0.4 seconds - 0.3 seconds a pulse period as shown at periods T1-T2, it will count a pulse per two shots.
[0003]
[Problem(s) to be Solved by the Invention] However, in the conventional pitchometer, since mask time amount is set up according to the pitch at the time of transit, there is a trouble that the pitch at the time of a walk is immeasurable. That is, in the time of a walk, when mask time amount is set as 0.5 seconds since a pulse period becomes 0.6 seconds - 0.4 seconds as period T3 - T four show to drawing 14 (b) and a pitch is a part for 100 times/, the pulse of the 1st shot will be counted and misregistration of the pitch will be carried out.
[0004] So, in the conventional pitchometer, when it is going to measure any pitch at the time of transit and a walk, the external actuation which switches a setup of mask time amount is required of the case where he walks with the case where it runs, and there is a trouble of being user-unfriendly.
[0005] In view of the above trouble, the technical problem of this invention can measure a pitch also in any at the time of transit and a walk, and, moreover, offering unnecessary pitchometer has the external actuation for switching conditioning between the times of walking with the time of running.
[0006]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, in the pitchometer concerning this invention In the analysis result of the body motion sensor which detects a body motion, a frequency-analysis means to carry out frequency analysis to the detection result of this body motion sensor, and this frequency-analysis means While power specifies the signal which exists more than predetermined level as a criteria wave for asking for a pitch in the field more than a predetermined frequency It judges whether this criteria wave is the 2nd higher harmonic over the fundamental wave of a body motion, or it is the 3rd higher harmonic. It is characterized by having a pitch operation means to ask for a pitch from the frequency when it judges that this criteria wave is the 2nd higher harmonic wave, and to calculate a pitch from the value which corresponds by 2/3 time the frequency when it judges that this criteria wave is the 3rd higher harmonic wave.
[0007] In this invention said pitch operation means For example, a 1st wave check means to judge whether there is any signal of the high level which has the frequency which corresponds by 1/3 time the frequency of said criteria wave, When it judges that there is no signal of the high level which has the frequency on which this 1st wave check means corresponds by 1/3 time the frequency of said criteria wave, it constitutes so that it may have a signal distinction means to judge said criteria wave to be the 2nd higher harmonic over said fundamental wave.
[0008] Moreover, a 2nd wave check means to judge whether said pitch operation means has the signal of the high level which has the frequency which corresponds by 2/3 time the frequency of

said criteria wave, When it judges that there is no signal of the high level which has the frequency on which this 2nd wave check means corresponds by 2/3 time the frequency of said criteria wave, it constitutes so that it may have a signal distinction means to judge said criteria wave to be the 2nd higher harmonic over said fundamental wave.

[0009] Moreover, a 1st wave check means to judge whether said pitch operation means has the signal of the high level which has the frequency which corresponds by 1/3 time the frequency of said criteria wave, It has a 2nd wave check means to judge whether there is any signal of the high level which has the frequency which corresponds by 2/3 time the frequency of said criteria wave. Said signal distinction means It is judged that there is no signal of the high level which has the frequency on which said 1st wave check means corresponds by 1/3 time the frequency of said criteria wave. And when it judges that there is no signal of the high level which has the frequency on which said 2nd wave check means corresponds by 2/3 time the frequency of said criteria wave, you may constitute so that said criteria wave may be judged to be the 2nd higher harmonic over said fundamental wave.

[0010] It is desirable to constitute so that it may conclude that said criteria wave is the 3rd higher harmonic wave over said fundamental wave when said criteria wave is judged to be the 3rd higher harmonic wave over said fundamental wave based on the check result of whether there is any signal of the high level which has a frequency equivalent to the multiple of the frequency of said criteria wave set to this invention and predetermined in said signal distinction means and it judges that it is more than frequency level predetermined in said criteria wave.

[0011]

[Embodiment of the Invention] One example of this invention is explained based on a drawing.

[0012] (Whole configuration) Drawing 1 is the explanatory view showing the configuration of the portable electronic device (pitchometer) of this example.

[0013] In drawing 1 , the profile configuration of the portable electronic device 1 of this example is carried out from the body 10 of equipment which has wrist watch structure, the cable 20 connected to this body 10 of equipment, and the sensor unit 30 for pulse wave detection prepared in the tip side of this cable 20. The connector piece 80 is constituted at the tip side of a cable 20, and this connector piece 80 can be freely detached and attached to the connector area 70 constituted at the 6:00 side of the body 10 of equipment. The body 10 of equipment can be freely detached [the wristband 12 which coils around an arm from 12:00 in a wrist watch, and is fixed to the body 10 of equipment in a direction at that 6:00 is formed, and] and attached on an arm with this wristband 12. From the root of an index finger before the knuckle is equipped with the sensor unit 30 for pulse wave detection, being shaded with the band 40 for sensor immobilization. Thus, if the root of a finger is equipped with the sensor unit 30 for pulse wave detection, since a cable 20 will be short and will end, a cable 20 does not become obstructive during running. Moreover, if distribution of the temperature from a palm to a fingertip is measured, when cold, the temperature of the root of a finger will not fall comparatively to the temperature of a fingertip falling remarkably. Therefore, even when equipping the root of a finger with the sensor unit 30 for pulse wave detection and it runs outdoors on a cold day, a pulse rate etc. can be measured correctly.

[0014] (Configuration of the body of equipment) The top view shown after drawing 2 has removed the body of equipment of the portable electronic device of this example for the wristband, the cable, etc., and drawing 3 are the side elevations which saw the portable electronic device from the direction of 3:00.

[0015] drawing 2 -- setting -- the body 10 of equipment -- the clock housing 11 (body case) made of resin -- having -- **** -- the front-face side of this clock housing 11 -- current time and a date -- in addition, the liquid crystal display 13 (display) with EL back light which displays pulse wave information, such as a pitch at the time of transit and a walk and a pulse rate, etc. is constituted. The 1st segment viewing area 131 located in the upper left side of the screen, the 2nd segment viewing area 132 located in an upper right side, the 3rd segment viewing area 133 located in a lower right side, and the dot viewing area 134 located in a lower left side are constituted by the liquid crystal display 13, and graphical display is possible in various kinds of information in the dot viewing area 134.

[0016] The body motion sensor 90 for asking for a pitch is built in the interior of clock housing 11, and an acceleration sensor etc. can be used as this body motion sensor 90. Moreover, while asking for change of a pulse rate etc. based on the detection result (pulse wave signal) by the sensor unit 30 for pulse wave detection while asking the interior of clock housing 11 for a pitch based on the detection result (body motion signal) by the body motion sensor 90 in order to display it on it with a liquid crystal display 13 and, in order to display it with a liquid crystal display 13, the control section 5 which performs various kinds of control and data processing is constituted. a control section 5 -- a time check -- since the circuit is also constituted, time of day, a lap time, split time, etc. can usually be displayed on a liquid crystal display 13.
[0017] The button switches 111-115 for performing external actuation of time-of-day doubling, a switch of a display mode, etc. are constituted by the periphery section of clock housing 11. Moreover, the larger button switches 116 and 117 are constituted on the surface of clock housing.
[0018] The power source of a portable electronic device 1 is the small cell 59 of the carbon button form built in clock housing 11, and a cable 20 has inputted the detection result of the sensor unit 30 for pulse wave detection into the control section 5 of clock housing 11 while supplying power to the sensor unit 30 for pulse wave detection from a cell 59.
[0019] Although it is necessary to follow on increasing the function and to enlarge the body 10 of equipment in a portable electronic device 1, since there is constraint that an arm is equipped, if the body 10 of equipment is turned in the direction of 6:00 in a wrist watch, and 12:00, it is unexpandable to the body 10 of equipment. So, in this example, the oblong clock housing 11 with the die-length dimension longer than the die-length dimension in the direction which it will be in 6:00 and 12:00 in the direction of 3:00 and 9:00 is used for the body 10 of equipment. However, although a wristband 12 has the big overhang part 101 in the direction of 9:00 in a wrist watch in view of a wristband 12 since it has connected in the location which inclined toward the direction side of 3:00, the starting big overhang part does not have it in the direction of 3:00. Therefore, the back of a hand is not thrown at clock housing 11, although a wrist can be bent freely comparatively using the oblong clock housing 11 and it falls over at it.
[0020] In the interior of clock housing 11, the flat piezoelectric device 58 for buzzers is arranged in the direction of 9:00 to the cell 59. Since it is heavy as compared with a piezoelectric device 58, a cell 59 has the center-of-gravity location of the body 10 of equipment in the location which inclined in the direction of 3:00. Since the wristband 12 has connected with the side toward which this center of gravity inclines, it can equip with the body 10 of equipment in the condition of having been stabilized on the arm. Moreover, since the cell 59 and the piezoelectric device 58 are arranged in the direction of a field, while being able to carry out [thin shape]-izing of the body 10 of equipment, as shown in drawing 3 , a user can exchange a cell 59 easily by forming the cell lid 118 in the flesh-side surface part 119.
[0021] (Wearing structure to the arm of the body of equipment) In drawing 3 , the connection section 105 for holding the stop shaft 121 attached in the edge of a wristband 12 is formed in the direction of 12:00 of clock housing 11. While the wristband 12 wound around the arm is turned up in the direction of 6:00 of clock housing 11 in a location in the middle of the die-length direction, the receptacle section 106 in which the fastener 122 for holding a location this middle is attached is formed in it.
[0022] In the direction of 6:00 of the body 10 of equipment, the part which receives from the flesh-side surface part 119, and results in the section 106 is the niting section 108 which is fabricated by clock housing 11 and one and makes the include angle of about 115 degrees to the flesh-side surface part 119. That is, when it equips with the body 10 of equipment so that it may be located in the top-face section L1 (back side of a hand) of the right wrist L (arm), while the flesh-side surface part 119 of clock housing 11 sticks it to the top-face section L1 of Wrist L with a wristband 12, the niting section 108 contacts the lateral portion L2 with Radius R. In this condition, while the flesh-side surface part 119 of the body 10 of equipment is in the sensibility over Ulna U as Radius R, if it applies to the niting section 108 of the niting section 108 and the flesh-side surface part 119 from a part for a flection 109, it becomes the sensibility which contacts Radius R. Thus, since [which it says is about 115 degrees with the niting section 108 and the flesh-side surface part 119] the ideal include angle is made anatomically, even if it is

going to turn the body 10 of equipment in the direction of an arrow head A or an arrow head B, the body 10 of equipment does not shift the surroundings of Arm L superfluously. Moreover, while the niting effectiveness is certainly acquired since the flesh-side surface part 119 and the niting section 108 touch an arm certainly even if an arm is thin in order to only regulate rotation of the body 10 of equipment at two surrounding one side of an arm by the flesh-side surface part 119 and the niting section 108, even if an arm is thick, there is no stiff sensibility.

[0023] (Configuration of the sensor unit for pulse wave detection) Drawing 4 is the sectional view of the sensor unit for pulse wave detection of this example.

[0024] in drawing 4 , as for the sensor unit 30 for pulse wave detection, the back lid 302 should cover the background of the sensor frame 36 as the case object -- the components storage space 300 is constituted by ****** inside. The circuit board 35 is arranged inside the components storage space 300. The electronic parts of LED31, a photo transistor 32, and others are mounted in the circuit board 35. The edge of a cable 20 is fixed to the sensor unit 30 for pulse wave detection by the bush 393, and each wiring of a cable 20 is soldered on the pattern of each circuit board 35 at it. Here, the sensor unit 30 for pulse wave detection is attached in a finger as a cable 20 is pulled out from the root side of a finger at the body 10 side of equipment. Therefore, LED31 and a photo transistor 32 will be arranged along the die-length direction of a finger, among those LED31 is located in the tip side of a finger, and a photo transistor 32 is located in the direction of the root of a finger. Thus, when it arranges, it is effective in the ability of outdoor daylight not to reach a photo transistor 32 easily.

[0025] In the sensor unit 30 for pulse wave detection, with the translucent plate 34 which becomes the top-face part (substantial pulse wave signal detecting element) of the sensor frame 36 from a glass plate, the light transmission aperture was formed and, as for LED31 and a photo transistor 32, the luminescence side and the light-receiving side are turned to the direction of a translucent plate 34 to this translucent plate 34, respectively. For this reason, if a finger front face is stuck on the outside front face 341 (the contact surface / sensor side on the front face of a finger) of a translucent plate 34, while LED31 emits light towards a finger front-face side, a photo transistor 32 can receive the light reflected from a finger side among the light which LED31 emitted. Here, the outside front face 341 of a translucent plate 34 has structure projected from the perimeter part 361 at the purpose which raises the adhesion on the outside front face 341 of a translucent plate 34, and the front face of a finger.

[0026] In this example, as LED31, blue LED of an InGaN system (indium-gallium-nitrogen system) is used, the emission spectrum has a luminescence peak in 450nm, and the luminescence wavelength field is located in the range from 350nm to 600nm. It is made to correspond to LED31 which has this luminescence property, and in this example, as a photo transistor 32, the photo transistor of a GaAsP system (gallium-arsenic-Lynn system) is used, the light-receiving wavelength field of a component own [the] has a main sensibility field in the range from 300nm to 600nm, and a sensibility field is in 300nm or less.

[0027] Thus, the root of a finger is equipped with the constituted sensor unit 30 for pulse wave detection with the band 40 for sensor immobilization, if light is irradiated towards a finger in this condition from LED31, this light will reach a blood vessel, a part of light will be absorbed by the hemoglobin in blood, and a part will reflect by it. The light reflected from the finger (blood vessel) is received by the photo transistor 32, and the light income change is equivalent to blood volume change (pulse wave of blood). That is, if blood volume decreases while the reflected light becomes weak, when there is much blood volume, since the reflected light will become strong, a pulse rate etc. is measurable if change of reflected light reinforcement is detected.

[0028] In this example, the light-receiving wavelength field has used the photo transistor 32 of the range from 300nm to 600nm with LED31 which has a luminescence wavelength field in the range from 350nm to 600nm, and biological information is displayed based on the detection result in the wavelength field from about 300nm to about 600nm which is the lap field, i.e., wavelength field about 700nm or less. If this sensor unit 30 for pulse wave detection is used, among the light by which outdoor daylight is contained in outdoor daylight in the exposed part of a finger, as for light 700nm or less, a wavelength field will make a finger a transparent material, and even a photo transistor 32 (light sensing portion) will not be reached. It is because the

wavelength field where the reason is included in outdoor daylight does not arrive to a photo transistor 32 through a finger even if outdoor daylight is irradiated by the part of the finger which is not covered in the band 40 for sensor immobilization since light 700nm or less cannot tend to penetrate a finger easily. On the other hand, if LED which has a luminescence peak, and the photo transistor of a silicon system are used near 880nm, the light-receiving wavelength range will reach the range from 350nm to 1200nm. In this case, since a pulse wave will be detected based on the detection result by light with a wavelength of 1 micrometer which reaches even a light sensing portion easily by making a finger into a transparent material, the incorrect detection resulting from fluctuation of outdoor daylight tends to take place.

[0029] Moreover, since pulse wave information has been acquired using the light of wavelength field about 700nm or less, the S/N ratio of the pulse wave signal based on blood volume change is high. As the reason, since it is large several times to about 100 or more times and wavelength changes with sensibility sufficient to blood volume change as compared with the absorbancy index to the light whose wavelength whose absorbancy index to the light from 300nm to 700nm is the conventional detection light is 880nm, the hemoglobin in blood is considered with since the detection ratio (S/N ratio) of the pulse wave based on blood volume change is high.

[0030] As shown in drawing 5 , (Configuration of a control section) To a control section 5 The pulse wave data-processing section 55 which asks for a pulse rate etc. based on the input result from the sensor unit 30 for pulse wave detection, The pitch data-processing section 56 which asks for a pitch based on the input result from the body motion sensor 90 is constituted. The pitch data-processing section 56 and the pulse wave data-processing section 55 By outputting information, such as a pitch and a pulse rate, the display of this information to a liquid crystal display 13 is enabled. In addition, a part of pitch data-processing section 56 and pulse wave data-processing section 55 consist of microcomputers which operate by the program stored, and the block diagram has shown it to drawing 5 about the function of this microcomputer.

[0031] First, in the pulse wave data-processing section 55, after pulse wave signal magnification and a transducer 551 amplify the signal inputted through the cable 20 from the sensor unit 30 for pulse wave detection, it changes into a digital signal and outputs to the pulse wave signal storage section 552. The pulse wave signal storage section 552 is RAM which memorizes the pulse wave data changed into the digital signal. The pulse wave signal operation part 553 reads the signal memorized by the pulse wave signal storage section 552, performs the fast Fourier transform (FFT processing) as frequency analysis to it, and inputs the result into the pulse wave component extract section 554. The pulse wave component extract section 554 extracts a pulse wave component from the input signal from the pulse wave signal operation part 553, outputs it to the pulse rate operation part 555, and this pulse rate operation part 555 calculates a pulse rate by the frequency component of the inputted pulse wave, and it outputs that result to a liquid crystal display 13.

[0032] Moreover, in the pitch data-processing section 56, after body motion signal magnification and a transducer 561 amplify the signal inputted from the body motion sensor 90, it changes into a digital signal and outputs to the body motion signal storage section 562. The body motion signal storage section 562 is RAM which memorizes the body motion data changed into the digital signal. The body motion signal operation part 563 reads the signal memorized by the body motion signal storage section 562, performs the fast Fourier transform (FFT processing) as frequency analysis to it, and inputs the result into the body motion component extract section 564. The body motion component extract section 564 extracts a body motion component from the input signal from the body motion signal operation part 563, outputs it to the pitch operation part 560, and this pitch operation part 560 calculates a pitch by the inputted frequency component of a body motion, and it outputs that result to a liquid crystal display 13.

[0033] (Configuration of pitch operation part) In the pitch operation part 560 The signal which has power in the field more than a predetermined frequency more than predetermined level as a criteria wave for asking for a pitch Whether there is any signal of the high level which has the signal specification section 565 to specify, the 1st wave check section 566 which judges whether there is any signal of the high level which has the frequency which corresponds by 1/3 time the frequency of a criteria wave, and the frequency which corresponds by 2/3 time the frequency of a

criteria wave The 2nd wave check section 567 to judge is constituted. furthermore, when it judges that there is no signal of the high level which has the frequency on which the 1st wave check section 566 corresponds by 1/3 time the frequency of a criteria wave in the pitch operation part 560 The signal distinction section 569 which judges a criteria wave to be the 2nd higher harmonic over the fundamental wave of a body motion is constituted. This signal distinction section 569 Also when the 2nd wave check section 567 judges that there is no signal of a high level in the location of the frequency which corresponds by 2/3 time the frequency of a criteria wave, it is constituted so that a criteria wave may be judged to be the 2nd higher harmonic over the fundamental wave of a body motion.

[0034] moreover, even when a criteria wave is judged to be the 3rd higher harmonic over a fundamental wave based on the check result of the 1st wave check section 566 and the 2nd wave check section 567, the signal distinction section 569 When it judges that it concludes that a criteria wave is the 3rd higher harmonic wave over a fundamental wave, and a criteria wave is below in predetermined frequency level for the first time when a criteria wave judges that it is more than predetermined frequency level, it is constituted so that it may conclude that a criteria wave is the 2nd higher harmonic wave over a fundamental wave.

[0035] In the constituted pitch operation part 560, thus, the signal outputted from the body motion signal operation part 563 and the body motion component extract section 564 [it has the spectrum as shown in drawing 6 (a) and (b), and / in quest of this spectrum to a pitch] the pitch operation part 553 It judges whether it is in a walk condition automatically from the difference between the spectrum at the time of a walk, and the spectrum at the time of transit, and whether it is in a run state, and asks for a pitch by performing the operation which was suitable in each case.

[0036] The principle is as follows. First, as compared with line spectrum SA1 corresponding to a fundamental wave, drawing 6 (a) is the typical spectrum at the time of transit, and its line spectrum SA2 which line spectrum SA1 corresponding to the fundamental wave of a body motion and line spectrum SA2 equivalent to the 2nd harmonic content to the fundamental wave of a body motion appear, among those is equivalent to the 2nd harmonic content is [level is remarkable and] high. It is because vertical movement comes out equally when the step of the left leg is carried out to the time of carrying out the step of the right leg at the time of transit, so the 2nd higher harmonic of a body motion component appears. Moreover, although the fundamental wave of the swing of an arm is equivalent to pendulum movement which makes a start and pull back of an arm a round term, only a part with it difficult [to make the swing of an arm smooth pendulum movement] at the time of transit is because the power of the fundamental wave of the swing of an arm becomes weakness. Furthermore, since acceleration is applied to the start of an arm, and each moment of pull back, the 2nd higher harmonic is because it comes out more strongly than the fundamental wave of the swing of an arm.

[0037] On the other hand, drawing 6 (b) is the typical spectrum at the time of a walk, and line spectrum SB1 corresponding to the fundamental wave of a body motion, line spectrum SB2 equivalent to the 2nd harmonic content to the fundamental wave of a body motion, and line spectrum SB3 equivalent to the 3rd harmonic content to the fundamental wave of a body motion appear. At the time of this walk, the signal component to which there is no vertical movement in a body motion, and the time of transit originates in a gesture appears strongly, and that description appears in line spectrum SB1 corresponding to a fundamental wave. Consequently, although the ratio of each line spectrums SB1, SB2, and SB3 is not fixed, as compared with the time of transit, the ratio of line spectrum SB1 to line spectrum SB2 is strong at the time of a walk. Therefore, line spectrum SB1 corresponding to the fundamental wave of a body motion and line spectrum SB3 equivalent to the 3rd harmonic content have level higher than line spectrum SB2 equivalent to the 2nd harmonic content.

[0038] And line spectrum SA2 corresponding to the 2nd higher harmonic at the time of transit, line spectrum SB2 corresponding to the 2nd higher harmonic at the time of a walk, and line spectrum SB3 corresponding to the 3rd higher harmonic at the time of a walk usually appear in the above frequency domain by /100 times. Therefore, the above frequency domain is supervised by /100 times, and if it judges whether the signal of a high level is the 2nd higher harmonic over

a fundamental wave among the signals which appeared there, and whether it is the 3rd higher harmonic, it can distinguish whether it is in a run state, and whether it is in a walk condition. That is, at the time of a walk, since the 3rd higher harmonic wave over a fundamental wave appears in the above frequency domain as a signal of a high level by /100 times, if it can judge that this signal is the 3rd higher harmonic wave, the pitch at the time of a walk can be calculated from the value which hung 2/3 time on the frequency of this signal. On the contrary, at the time of transit, since the 2nd higher harmonic wave over a fundamental wave appears in the above frequency domain as a signal of a high level by /100 times, if it can judge that this signal is the 2nd higher harmonic wave, it can ask for the pitch at the time of transit from the frequency of this signal.

[0039] Then, the pitch operation part 560 performs processing based on the flow chart shown in drawing 7 using the difference between the pattern at the time of transit of this spectrum, and the pattern at the time of a walk, and asks for a pitch.

[0040] First, at a step ST 1, the highest signal (line spectrum) of level is found from the spectrum after a frequency analysis. This signal is the candidate of the signal which should serve as a criteria wave for asking for a pitch. At a step ST 2, the frequency of this criteria wave judges [100 times] whether it is above by /.

[0041] Here, 100 times, if the frequency of a criteria wave is the following by /, it will find another candidate in a step ST 3, and it finds a signal with the highest level as a criteria wave out of the signal except a previous signal in a step ST 4. When a suitable signal is not found, in this processing, in a step ST 5, the pitch measured last time is made into this pitch as it is, and this value is decided as a pitch in a step ST 6.

[0042] On the other hand, if the signal of the above high level is found by /100 times while performing processing at steps ST3 and ST4, it will judge whether there is any signal which makes this signal a criteria wave, and has a frequency 1/3 time the frequency of this criteria wave at a step ST 7, and has the amplitude of 1/2 twice or more to criteria wave amplitude.

[0043] When it has the frequency which corresponds by 1/3 time the frequency of a criteria wave at a step ST 7 and there is no signal of the amplitude of 1/2 twice or more to criteria wave amplitude, in a step ST 8, it judges whether there is any signal which has the frequency which corresponds by 2/3 time the frequency of a criteria wave, and has the amplitude of 1/2 twice or more to criteria wave amplitude.

[0044] If it has the frequency which corresponds by 1/3 time the frequency of a criteria wave at a step ST 8 and there is no signal of the amplitude of 1/2 twice or more to criteria wave amplitude, since a criteria wave can be judged to be a signal equivalent to the 2nd harmonic content, it will decide this value as a pitch as it is in a step ST 6.

[0045] On the other hand, in a step ST 7, when it has the frequency which corresponds by 1/3 time the frequency of a criteria wave and there is a signal of the amplitude of 1/2 twice or more to criteria wave amplitude, in a step ST 9, it judges whether the frequency of this criteria wave is above by 150 times/. This 150 time, the value of a part for /was a 1.5 times [for /] as many 100 times numeric value as this, in the usual case, the pitch during a walk was a part for part [for 100 times/-], and 150 times/, and 150 times, a part for /-, and 200 times, since the pitch under transit was a part for /, it was used for reconfirmation of a walk condition or a run state bordering on the numeric value of a part for /150 times. Therefore, in a step ST 9, when the frequency of a criteria wave judges that it is above by /150 times, this criteria wave can be checked as it is the 3rd higher harmonic over the fundamental wave at the time of a walk. So, since it can be concluded that a criteria wave is a signal equivalent to the 3rd harmonic content, in a step ST 10, it doubles the frequency of this signal 2/3, and decides as a pitch this value doubled 2/3 in a step ST 6.

[0046] Moreover, even when it has the frequency which corresponds by 1/3 time the frequency of a criteria wave in a step ST 7 and there is no signal of the amplitude of 1/2 twice or more to criteria wave amplitude, it sets to a step ST 8. When it is judged that it has the frequency which corresponds by 2/3 time the frequency of a criteria wave, and there is a signal of the amplitude of 1/2 twice or more to criteria wave amplitude In a step ST 9, when it judges whether the frequency of this criteria wave is above by 150 times/and the frequency of a criteria wave judges

that it is above by /150 times, this criteria wave can be checked as it is the 3rd higher harmonic over the fundamental wave at the time of a walk. So, since it can be concluded that a criteria wave is a signal equivalent to the 3rd harmonic content, in a step ST 10, it doubles the frequency of this signal 2/3, and decides as a pitch this value doubled 2/3 in a step ST 6.

[0047] However, in a step ST 9, if the frequency of this criteria wave is the value of the following by 150 times/, it can be judged that a criteria wave is not a signal equivalent to the 3rd harmonic content. Therefore, the signal which has one 1/3 time of this criteria wave or 2/3 time the frequency of this is a noise to the last, and it can be judged that a criteria wave is the 2nd harmonic content. Therefore, in a step ST 6, this value is decided as a pitch as it is.

[0048] Thus, when there is no signal of the amplitude of 1/2 twice or more in the location of the frequency which there is no signal of the amplitude of 1/2 twice or more in the location of the frequency which corresponds by 1/3 time the frequency of a criteria wave to criteria wave amplitude, and is equivalent to it 2/3 time of the frequency of a criteria wave to criteria wave amplitude, a criteria wave is judged to be the 2nd higher harmonic. However, if they are noises even when the signal of the amplitude of 1/2 twice or more is in the location of the frequency which the signal of the amplitude of 1/2 twice or more is in the location of the frequency which corresponds by 1/3 time the frequency of a criteria wave to criteria wave amplitude, or corresponds by 2/3 time the frequency of a criteria wave to criteria wave amplitude, it will be judged that it is the 3rd higher harmonic accidentally. If the pitch at the time of a walk is in the range for /at all a part for /-, and 150 times 100 times, in this example, usually then, the 3rd higher harmonic at the time of a walk As a frequency appearing to the above field by /150 times, the frequency of a criteria wave judges [150 times] whether it is above by /, and when the frequency of a criteria wave judges that it is above by /150 times, it is concluded that a criteria wave is the 3rd higher harmonic for the first time.

[0049] (Actuation of a portable electronic device) Since the portable electronic device 1 of this example is further switched to clock mode, stop watch mode, the pulsometer mode that combines with a time check and measures pulse wave information, and the mode which measures a pitch, it explains each mode of the portable electronic device 1 of this example.

[0050] The contents of a display in each mode performed with a portable electronic device 1 and the liquid crystal display 13 at that time are typically expressed to drawing 8 .

[0051] In drawing 8 , a step ST 11 is in clock mode, the purport which are December 6, 1994 and Monday is displayed on the 1st segment viewing area 131, and the purport whose current time is 10:08 p.m. 59 seconds is displayed on the 2nd segment viewing area 132. It is displayed on the dot viewing area 134 as "TIME" noting that the current mode is clock mode. However, in the dot viewing area 134, for several seconds immediately after choosing this clock mode is displayed as "TIME" as mentioned later. In addition, nothing is displayed on the 3rd segment viewing area 133.

[0052] In the portable electronic device 1 of this example, if the button switch 111 which is in a direction at 2:00 is pushed at the time of clock mode, when 1 hour passes, for example, an alarm sound can be generated, and the generating time of day of this alarm can be set as arbitration. Moreover, if the button switch 113 which is in a direction at 11:00 is pushed, EL back light of a liquid crystal display 13 will light up for 3 seconds, and the light will be put out automatically after an appropriate time.

[0053] If the button switch 112 which exists in the direction of 4:00 from this mode is pushed, it will switch to running mode (step ST 12). This mode is the mode when using a portable electronic device 1 as stop watch. In running mode, before starting measurement (standby condition), current time is displayed on the 1st segment viewing area 131, and it is displayed on the 2nd segment viewing area 132 as "0:00':00":00." In the dot viewing area 134, a graphic switches, after displaying for 2 seconds as "RUN" as guidance of the purport which is in running mode.

[0054] If the button switch 112 which exists in the direction of 4:00 from this mode is pushed, it will switch to the recall mode (step ST 13) of a lap time. This mode is the mode which reads the lap time measured in the past using the portable electronic device 1, and split time. In the recall mode of a lap time, the date is displayed on the 1st segment viewing area 131, and current time is displayed on the 2nd segment viewing area 132. For 2 seconds is displayed on the dot viewing

area 134 as "LAP/RECALL" as guidance of the purport which is in recall mode, next transition of the pulse rate for every newest lap is displayed on it.

[0055] If the button switch 112 which exists in the direction of 4:00 from this mode is pushed, it will switch to the recall mode (step ST 14) of a pulse wave measurement result. This mode is the mode which reads the temporal response of the pulse rate which the marathon performed in the past used the portable electronic device 1 at the time, and was measured and memorized, and the temporal response of the pitch measured in the past using the portable electronic device 1. In this recall mode, the date is displayed on the 1st segment viewing area 131, and current time is displayed on the 2nd segment viewing area 132. The graph with which for 2 seconds is displayed as "RESULT/RECALL", next the temporal response of an average pulse rate is expressed is displayed on the dot viewing area 134.

[0056] If the button switch 112 which exists in the direction of 4:00 is again pushed from this mode, as an arrow head P1 shows, it will return to clock mode (step ST 11). Moreover, in steps ST12-ST14, also when the condition that there is no input continues for 10 minutes, as an arrow head P2 shows, it returns to clock mode (step ST 11) automatically. When it returns to this clock mode, the date is displayed on the 1st segment viewing area 131, and current time is displayed on the 2nd segment viewing area 132.

[0057] Although it is displayed as "TIME" noting that it returns to clock mode so that it may expand to the dot viewing area 134 at <u>drawing 9</u> (a) when it becomes clock mode in this example, and it may be shown, as this annunciator is shown in <u>drawing 9</u> (b), it will disappear automatically after 2 seconds, and it will be in the normal state (step ST 15) in clock mode. In the normal state in this clock mode, it is still the condition that nothing is displayed on the dot viewing area 134. That is, power-saving is attained by only necessary minimum time amount's indicating by the dot showing a user to the mode, and considering as the mode display of the purport that whose that has disappeared itself it is the normal state in clock mode.

[0058] In the portable electronic device 1 of this example, if it equips with the connector piece 80 to a connector area 70, as an arrow head P3 shows to <u>drawing 8</u> , it will switch from any condition to running mode (step ST 12) automatically. The running mode at this time not only operates as stop watch, but is the mode which can measure the pitch and pulse rate under running.

[0059] With reference to the function in the running mode as pitchometer and pulsometer, it explains focusing on <u>drawing 10</u> .

[0060] First, in <u>drawing 10</u> , if it switches to the running mode as pitchometer and pulsometer (step ST 31), as shown in <u>drawing 11</u> (a), current time will be displayed on the 1st segment viewing area 131 of a liquid crystal display, and it will be displayed on the 2nd segment viewing area 132 as "0:00':00":00", and will be displayed on the dot viewing area 134 as "RUN." Moreover, it indicates that the mark of the heart blinked by the 3rd segment viewing area 133, and it switched to the running mode as pitchometer and pulsometer.

[0061] Power is supplied to the pulse wave data-processing section 55 etc. by switch in this mode, and initialization processing called a setup of a period of operation etc. is performed by it. And incorporation of the pulse wave signal for measuring an early pulse rate after 2 seconds is performed. the display (step ST 32) with "STOP/5" and the display (step ST 33) with "MOTION/4" are performed to the dot viewing area 134 by turns, and seem not to move by 2Hz to it for 5 seconds at this time -- ** -- it is displayed. The figure displayed at this time is the count-down to for 5 seconds, and switches. And it will be in a standby condition until the button switch 117 located in the body of equipment 10 front-face bottom is pushed so that measurement of time amount may be started (step ST 34).

[0062] In the state of this standby, as shown in <u>drawing 11</u> (b), graphical display of the original wave of a pulse wave signal is carried out to the dot viewing area 134. The original wave displayed here is the newest data. Therefore, if the wave of a original wave of a pulse wave signal and level are checked before starting measurement (marathon) of time amount, the quality of the wearing condition of LED31 or a photo transistor 32 can be distinguished in detail. Moreover, the location of LED31 or a photo transistor 32 can also be set as the optimal location by adjusting LED31 and a photo transistor 32, checking the configuration and level of a original wave. And it

can check beforehand whether it is the environment which can measure surrounding temperature and humidity. Furthermore, this function is applicable to the inspection etc. at the time of manufacture of a portable electronic device 1. Moreover, since graphical display of the original wave is carried out, it can also check whether the time-axis has been changed by consumption of a cell etc. In addition, the early pulse rate "75" for which it asked from pulse conversion is displayed on the 3rd segment viewing area 132.
[0063] While measurement of elapsed time will be started from this condition if the button switch 117 located in the body of equipment 10 front-face bottom is pushed at the same time it starts marathon, measurement of a pitch and a pulse rate is performed (step ST 35).
[0064] As these measurement results were shown in drawing 12 (a), first, elapsed time is displayed on the 2nd segment viewing area 132, and graphical display of the temporal response of a pulse rate is carried out to the dot viewing area 134. The graphical display performed at this time is a display by the bar graph prolonged in the upper part from a lower part by making the abbreviation mid-position of an axis of ordinate into a pulse rate 65. In the meantime, the graduation and the pulse rate at the time of the axis of ordinate of the graph displayed on the dot viewing area 134 are displayed on the 3rd segment viewing area 133.
[0065] When a pulse rate enters in a range (assignment within the limits to pulse rates 120-168), as it is shown in drawing 12 R> 2 (b) in this condition, graphical display of the pulse rate is carried out as a difference over the criteria pulse rate set up beforehand (step ST 36). The graphical display performed at this time is a display by the bar graph prolonged in the upper and lower sides (forward and the negative direction) in the part which is equivalent to a difference from this value by making the abbreviation mid-position of an axis of ordinate into a pulse rate 150. Moreover, the mark which shows the appointed range of a pulse rate is displayed on the right-hand side edge of the dot viewing area 134.
[0066] A push on the button switch 114 which is in a direction at 8:00 in the meantime carries out graphical display of the temporal response of a pitch to the dot viewing area 134 (step ST 37). The graphical display performed at this time is the line graph which made the pitch 170 the abbreviation mid-position of an axis of ordinate, as shown in drawing 12 (c). At this time, the graduation (purport whose abbreviation mid-position of an axis of ordinate is the pitch 170) and the pitch at the time of the axis of ordinate of the graph displayed on the dot viewing area 134 are displayed on the 3rd segment viewing area 133. Thus, in the portable electronic device 1 of this example, in the dot viewing area 134, since it has displayed with a different gestalt from the display of a pulse rate called a line graph etc. in the temporal response of a pitch, a runner can distinguish easily whether the current display shows which information only by seeing the display gestalt.
[0067] If the button switch 114 which is in a direction at 8:00 is again pushed from this condition, it will return to the condition (step ST 36) that the temporal response of a pulse rate is displayed on the dot viewing area 134.
[0068] Moreover, if the button switch 116 located in the body of equipment 10 front-face bottom is pushed when it passes along a predetermined shunt, the lap time at that time will be displayed on the 1st segment viewing area 131 (step ST 38). And after 10 seconds, it returns to a step ST 36 automatically.
[0069] If the button switch 117 located in the body of equipment 10 front-face bottom is pushed at the same time it reaches gall after an appropriate time, measurement of a pulse rate, a pitch, and time amount will stop, and it will be displayed on the dot viewing area 134 as "COOLING/DOWN" (step ST 39). If 2 minutes pass since this condition, graphical display of the temporal response of the pulse rate after making a goal will be carried out to the dot viewing area 134 as a pulse recovery property (step ST 40).
[0070] The graphical display about this pulse recovery property switches to the bar graph display prolonged upwards from the bottom first with the graduation which made the abbreviation mid-position of an axis of ordinate the pulse rate 150, as shown in drawing 13 (a). And as shown in drawing 13 (b), the recovery property for 2 minutes is measured. In the meantime, the graduation and the pulse rate at the time of the axis of ordinate of the graph displayed on the dot viewing area 134 are displayed on the 3rd segment viewing area 133.

[0071] If the button switch 114 which is in a direction at 8:00 is pushed from this condition, after being displayed on the dot viewing area 134 as "PULSE/RESULT" for 1.5 seconds (step ST 41), the temporal response of the pulse rate in this marathon will be displayed on the dot viewing area 134 (step ST 42). Moreover, if the button switch 114 which is in a direction at 8:00 is pushed, after being displayed on the dot viewing area 134 as "PITCH/RESULT" for 1.5 seconds (step ST 43), the temporal response of the pitch in this marathon will be displayed on the dot viewing area 134 (step ST 44). Furthermore, if the button switch 114 which is in a direction at 8:00 is pushed, after being displayed on the dot viewing area 134 as "COOLING/DOWN" for 1.5 seconds (step ST 45), it will return to the condition (step ST 40) that graphical display of the temporal response of the pulse rate after reaching the dot viewing area 134 is carried out as a pulse recovery property.
[0072] After making a goal, when the button switch 116 located in the body of equipment 10 front-face bottom is pushed, in addition, to the dot viewing area 134 If guidance "PROTECT/MEMO?Y" of whether to memorize this result is displayed (step ST 46), the button switch 117 located in the body of equipment 10 front-face bottom is pushed and "YES" is answered It is displayed on it as "MEMORY" noting that a result is storage processed in the dot viewing area 134 (step ST 47), and after 2 seconds, it returns to an initial state (step ST 31).
[0073] If the button switch 112 which exists in the direction of 4:00 is pushed after the measurement as this pitchometer and pulsometer is completed, as shown in drawing 8 , it will switch to the recall mode (step ST 13) of a lap time. If the button switch 112 which exists in the direction of 4:00 is pushed from this mode, it will switch to the recall mode (step ST 14) of a pulse wave measurement result. Also in this mode, graphical display of the temporal response of a pitch and a pulse rate can be carried out to the dot viewing area 134. If the button switch 112 which exists in the direction of 4:00 is pushed from this condition, it will return to clock mode (step ST 11).
[0074] Also when it returns to this mode, the date is displayed on the 1st segment viewing area 133, and current time is displayed on the 2nd segment viewing area 132. Moreover, although an annunciator with "TIME" is performed to the dot viewing area 134 noting that it returns to clock mode, as an arrow head P4 shows, after 2 seconds, this display will disappear automatically and will be in the normal state (step ST 15) in clock mode.
[0075] In the spectrum after carrying out frequency analysis of the body motion signal as mentioned above by /100 times (The main effectiveness of an example) In the above frequency domain At the time of transit, the 2nd higher harmonic wave over a fundamental wave appears as a signal of a high level. At the time of a walk, it finds out that the 3rd higher harmonic wave over a fundamental wave appears as a signal of a high level, and is based on this knowledge. In the portable electronic device 1 of this example The signal of this high level in the 2nd higher harmonic over the fundamental wave at the time of transit Or when it judges it that it asks and a criteria wave is a signal as the 2nd higher harmonic whether it is the 3rd higher harmonic over the fundamental wave at the time of a walk, it asks for a pitch from the frequency. When it judges that a criteria wave is a signal as the 3rd higher harmonic, a pitch is calculated from the value which corresponds by 2/3 time the frequency. Therefore, since the external actuation for switching the mode in the time of walking with the time of running is unnecessary while being able to ask for a pitch correctly by easy and quick processing in any [at the time of transit and a walk] case, it is user-friendly.
[0076] Moreover, in this example, when the signal of the amplitude of 1/2 twice or more is in the location of the frequency which corresponds 1/3 time of the frequency of a criteria wave, or 2/3 time to criteria wave amplitude, and the frequency of a criteria wave judges that it is above by /150 times, it is concluded that a criteria wave is the 3rd higher harmonic for the first time. Thus, since it judges whether it is the 2nd higher harmonic or it is the 3rd higher harmonic, double-checking, the decision which made the mistake in originating in a noise etc. can be prevented.
[0077]
[Effect of the Invention] As mentioned above, in the pitchometer concerning this invention, it has the description in the spectrum after carrying out frequency analysis of the body motion signal to ask for whether the high level which appears in the above frequency domain by /100 times is the

3rd higher harmonic over the fundamental wave at the 2nd higher harmonic over the fundamental wave at the time of transit, or the time of a walk, and ask for a pitch automatically from the result. Therefore, since according to this invention the external actuation for switching the mode in the time of walking with the time of running is unnecessary while being able to ask for a pitch correctly and quickly in any [at the time of transit and a walk] case, it is user-friendly.
[0078] In furthermore, the location of the frequency which corresponds 1/3 time of the frequency of a criteria wave, or 2/3 time When it judges that the frequency of a criteria wave is more than predetermined frequency level even when there is a signal of a high level and constitutes for the first time so that it may conclude that a criteria wave is the 3rd higher harmonic Since it judges whether it is the 2nd higher harmonic or it is the 3rd higher harmonic, double-checking, the decision which made the mistake in originating in a noise etc. can be prevented.

TECHNICAL FIELD

[Field of the Invention] This invention relates to the technique for asking for a pitch in more detail about pitchometer from the body motion signal detected at the time of transit or a walk.

PRIOR ART

[Description of the Prior Art] In pitchometer, by the acceleration sensor built in it, a body motion signal is detected and it is asking for the pitch from this body motion signal. For example, if pulse conversion is carried out after amplifying a body motion signal, the pulse shape shown in drawing 14 (a) will be obtained. Thus, an error is large although there is the approach of setting up a predetermined threshold from pulse separation being irregular according to a run state, and counting a pulse in the obtained pulse shape. Then, as shown in drawing 14 (b), in case a pulse is counted, by setting up mask time amount, a pulse is counted per two shots and the approach of raising detection precision is used. For example, if a pulse period counts the pitch at the time of transit as a pulse which is 0.8 seconds - 0.6 seconds by usually setting mask time amount as 0.5 seconds a part for /-, and 200 times 150 times since it is a part for /and is 0.4 seconds - 0.3 seconds a pulse period as shown at periods T1-T2, it will count a pulse per two shots.

EFFECT OF THE INVENTION

In the spectrum after carrying out frequency analysis of the body motion signal as mentioned above by /100 times (The main effectiveness of an example) In the above frequency domain At the time of transit, the 2nd higher harmonic wave over a fundamental wave appears as a signal of a high level. At the time of a walk, it finds out that the 3rd higher harmonic wave over a fundamental wave appears as a signal of a high level, and is based on this knowledge. In the portable electronic device 1 of this example The signal of this high level in the 2nd higher harmonic over the fundamental wave at the time of transit Or when it judges it that it asks and a criteria wave is a signal as the 2nd higher harmonic whether it is the 3rd higher harmonic over the fundamental wave at the time of a walk, it asks for a pitch from the frequency. When it judges that a criteria wave is a signal as the 3rd higher harmonic, a pitch is calculated from the value which corresponds by 2/3 time the frequency. Therefore, since the external actuation for switching the mode in the time of walking with the time of running is unnecessary while being able to ask for a pitch correctly by easy and quick processing in any [at the time of transit and a walk] case, it is user-friendly.
[0076] Moreover, in this example, when the signal of the amplitude of 1/2 twice or more is in the location of the frequency which corresponds 1/3 time of the frequency of a criteria wave, or 2/3 time to criteria wave amplitude, and the frequency of a criteria wave judges that it is above by /150 times, it is concluded that a criteria wave is the 3rd higher harmonic for the first time. Thus, since it judges whether it is the 2nd higher harmonic or it is the 3rd higher harmonic,

double-checking, the decision which made the mistake in originating in a noise etc. can be prevented.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, in the conventional pitchometer, since mask time amount is set up according to the pitch at the time of transit, there is a trouble that the pitch at the time of a walk is immeasurable. That is, in the time of a walk, when mask time amount is set as 0.5 seconds since a pulse period becomes 0.6 seconds - 0.4 seconds as period T3 - T four show to drawing 14 (b) and a pitch is a part for 100 times/, the pulse of the 1st shot will be counted and misregistration of the pitch will be carried out.
[0004] So, in the conventional pitchometer, when it is going to measure any pitch at the time of transit and a walk, the external actuation which switches a setup of mask time amount is required of the case where he walks with the case where it runs, and there is a trouble of being user-unfriendly.
[0005] In view of the above trouble, the technical problem of this invention can measure a pitch also in any at the time of transit and a walk, and, moreover, offering unnecessary pitchometer has the external actuation for switching conditioning between the times of walking with the time of running.

MEANS

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, in the pitchometer concerning this invention In the analysis result of the body motion sensor which detects a body motion, a frequency-analysis means to carry out frequency analysis to the detection result of this body motion sensor, and this frequency-analysis means While power specifies the signal which exists more than predetermined level as a criteria wave for asking for a pitch in the field more than a predetermined frequency It judges whether this criteria wave is the 2nd higher harmonic over the fundamental wave of a body motion, or it is the 3rd higher harmonic. It is characterized by having a pitch operation means to ask for a pitch from the frequency when it judges that this criteria wave is the 2nd higher harmonic wave, and to calculate a pitch from the value which corresponds by 2/3 time the frequency when it judges that this criteria wave is the 3rd higher harmonic wave.
[0007] In this invention said pitch operation means For example, a 1st wave check means to judge whether there is any signal of the high level which has the frequency which corresponds by 1/3 time the frequency of said criteria wave, When it judges that there is no signal of the high level which has the frequency on which this 1st wave check means corresponds by 1/3 time the frequency of said criteria wave, it constitutes so that it may have a signal distinction means to judge said criteria wave to be the 2nd higher harmonic over said fundamental wave.
[0008] Moreover, a 2nd wave check means to judge whether said pitch operation means has the signal of the high level which has the frequency which corresponds by 2/3 time the frequency of said criteria wave, When it judges that there is no signal of the high level which has the frequency on which this 2nd wave check means corresponds by 2/3 time the frequency of said criteria wave, it constitutes so that it may have a signal distinction means to judge said criteria wave to be the 2nd higher harmonic over said fundamental wave.
[0009] Moreover, a 1st wave check means to judge whether said pitch operation means has the signal of the high level which has the frequency which corresponds by 1/3 time the frequency of said criteria wave, It has a 2nd wave check means to judge whether there is any signal of the high level which has the frequency which corresponds by 2/3 time the frequency of said criteria wave. Said signal distinction means It is judged that there is no signal of the high level which has the frequency on which said 1st wave check means corresponds by 1/3 time the frequency of said criteria wave. And when it judges that there is no signal of the high level which has the frequency on which said 2nd wave check means corresponds by 2/3 time the frequency of said

criteria wave, you may constitute so that said criteria wave may be judged to be the 2nd higher harmonic over said fundamental wave.

[0010] It is desirable to constitute so that it may conclude that said criteria wave is the 3rd higher harmonic wave over said fundamental wave when said criteria wave is judged to be the 3rd higher harmonic wave over said fundamental wave based on the check result of whether there is any signal of the high level which has a frequency equivalent to the multiple of the frequency of said criteria wave set to this invention and predetermined in said signal distinction means and it judges that it is more than frequency level predetermined in said criteria wave.

[0011]

[Embodiment of the Invention] One example of this invention is explained based on a drawing.

[0012] (Whole configuration) Drawing 1 is the explanatory view showing the configuration of the portable electronic device (pitchometer) of this example.

[0013] In drawing 1 , the profile configuration of the portable electronic device 1 of this example is carried out from the body 10 of equipment which has wrist watch structure, the cable 20 connected to this body 10 of equipment, and the sensor unit 30 for pulse wave detection prepared in the tip side of this cable 20. The connector piece 80 is constituted at the tip side of a cable 20, and this connector piece 80 can be freely detached and attached to the connector area 70 constituted at the 6:00 side of the body 10 of equipment. The body 10 of equipment can be freely detached [the wristband 12 which coils around an arm from 12:00 in a wrist watch, and is fixed to the body 10 of equipment in a direction at that 6:00 is formed, and] and attached on an arm with this wristband 12. From the root of an index finger before the knuckle is equipped with the sensor unit 30 for pulse wave detection, being shaded with the band 40 for sensor immobilization. Thus, if the root of a finger is equipped with the sensor unit 30 for pulse wave detection, since a cable 20 will be short and will end, a cable 20 does not become obstructive during running. Moreover, if distribution of the temperature from a palm to a fingertip is measured, when cold, the temperature of the root of a finger will not fall comparatively to the temperature of a fingertip falling remarkably. Therefore, even when equipping the root of a finger with the sensor unit 30 for pulse wave detection and it runs outdoors on a cold day, a pulse rate etc. can be measured correctly.

[0014] (Configuration of the body of equipment) The top view shown after drawing 2 has removed the body of equipment of the portable electronic device of this example for the wristband, the cable, etc., and drawing 3 are the side elevations which saw the portable electronic device from the direction of 3:00.

[0015] drawing 2 -- setting -- the body 10 of equipment -- the clock housing 11 (body case) made of resin -- having -- **** -- the front-face side of this clock housing 11 -- current time and a date -- in addition, the liquid crystal display 13 (display) with EL back light which displays pulse wave information, such as a pitch at the time of transit and a walk and a pulse rate, etc. is constituted. The 1st segment viewing area 131 located in the upper left side of the screen, the 2nd segment viewing area 132 located in an upper right side, the 3rd segment viewing area 133 located in a lower right side, and the dot viewing area 134 located in a lower left side are constituted by the liquid crystal display 13, and graphical display is possible in various kinds of information in the dot viewing area 134.

[0016] The body motion sensor 90 for asking for a pitch is built in the interior of clock housing 11, and an acceleration sensor etc. can be used as this body motion sensor 90. Moreover, while asking for change of a pulse rate etc. based on the detection result (pulse wave signal) by the sensor unit 30 for pulse wave detection while asking the interior of clock housing 11 for a pitch based on the detection result (body motion signal) by the body motion sensor 90 in order to display it on it with a liquid crystal display 13 and, in order to display it with a liquid crystal display 13, the control section 5 which performs various kinds of control and data processing is constituted. a control section 5 -- a time check -- since the circuit is also constituted, time of day, a lap time, split time, etc. can usually be displayed on a liquid crystal display 13.

[0017] The button switches 111-115 for performing external actuation of time-of-day doubling, a switch of a display mode, etc. are constituted by the periphery section of clock housing 11. Moreover, the larger button switches 116 and 117 are constituted on the surface of clock housing.

[0018] The power source of a portable electronic device 1 is the small cell 59 of the carbon button form built in clock housing 11, and a cable 20 has inputted the detection result of the sensor unit 30 for pulse wave detection into the control section 5 of clock housing 11 while supplying power to the sensor unit 30 for pulse wave detection from a cell 59.
[0019] Although it is necessary to follow on increasing the function and to enlarge the body 10 of equipment in a portable electronic device 1, since there is constraint that an arm is equipped, if the body 10 of equipment is turned in the direction of 6:00 in a wrist watch, and 12:00, it is unexpandable to the body 10 of equipment. So, in this example, the oblong clock housing 11 with the die-length dimension longer than the die-length dimension in the direction which it will be in 6:00 and 12:00 in the direction of 3:00 and 9:00 is used for the body 10 of equipment. However, although a wristband 12 has the big overhang part 101 in the direction of 9:00 in a wrist watch in view of a wristband 12 since it has connected in the location which inclined toward the direction side of 3:00, the starting big overhang part does not have it in the direction of 3:00. Therefore, the back of a hand is not thrown at clock housing 11, although a wrist can be bent freely comparatively using the oblong clock housing 11 and it falls over at it.
[0020] In the interior of clock housing 11, the flat piezoelectric device 58 for buzzers is arranged in the direction of 9:00 to the cell 59. Since it is heavy as compared with a piezoelectric device 58, a cell 59 has the center-of-gravity location of the body 10 of equipment in the location which inclined in the direction of 3:00. Since the wristband 12 has connected with the side toward which this center of gravity inclines, it can equip with the body 10 of equipment in the condition of having been stabilized on the arm. Moreover, since the cell 59 and the piezoelectric device 58 are arranged in the direction of a field, while being able to carry out [thin shape]-izing of the body 10 of equipment, as shown in drawing 3 , a user can exchange a cell 59 easily by forming the cell lid 118 in the flesh-side surface part 119.
[0021] (Wearing structure to the arm of the body of equipment) In drawing 3 , the connection section 105 for holding the stop shaft 121 attached in the edge of a wristband 12 is formed in the direction of 12:00 of clock housing 11. While the wristband 12 wound around the arm is turned up in the direction of 6:00 of clock housing 11 in a location in the middle of the die-length direction, the receptacle section 106 in which the fastener 122 for holding a location this middle is attached is formed in it.
[0022] In the direction of 6:00 of the body 10 of equipment, the part which receives from the flesh-side surface part 119, and results in the section 106 is the niting section 108 which is fabricated by clock housing 11 and one and makes the include angle of about 115 degrees to the flesh-side surface part 119. That is, when it equips with the body 10 of equipment so that it may be located in the top-face section L1 (back side of a hand) of the right wrist L (arm), while the flesh-side surface part 119 of clock housing 11 sticks it to the top-face section L1 of Wrist L with a wristband 12, the niting section 108 contacts the lateral portion L2 with Radius R. In this condition, while the flesh-side surface part 119 of the body 10 of equipment is in the sensibility over Ulna U as Radius R, if it applies to the niting section 108 of the niting section 108 and the flesh-side surface part 119 from a part for a flection 109, it becomes the sensibility which contacts Radius R. Thus, since [which it says is about 115 degrees with the niting section 108 and the flesh-side surface part 119] the ideal include angle is made anatomically, even if it is going to turn the body 10 of equipment in the direction of an arrow head A or an arrow head B, the body 10 of equipment does not shift the surroundings of Arm L superfluously. Moreover, while the niting effectiveness is certainly acquired since the flesh-side surface part 119 and the niting section 108 touch an arm certainly even if an arm is thin in order to only regulate rotation of the body 10 of equipment at two surrounding one side of an arm by the flesh-side surface part 119 and the niting section 108, even if an arm is thick, there is no stiff sensibility.
[0023] (Configuration of the sensor unit for pulse wave detection) Drawing 4 is the sectional view of the sensor unit for pulse wave detection of this example.
[0024] in drawing 4 , as for the sensor unit 30 for pulse wave detection, the back lid 302 should cover the background of the sensor frame 36 as the case object -- the components storage space 300 is constituted by ****** inside. The circuit board 35 is arranged inside the components storage space 300. The electronic parts of LED31, a photo transistor 32, and others are mounted

in the circuit board 35. The edge of a cable 20 is fixed to the sensor unit 30 for pulse wave detection by the bush 393, and each wiring of a cable 20 is soldered on the pattern of each circuit board 35 at it. Here, the sensor unit 30 for pulse wave detection is attached in a finger as a cable 20 is pulled out from the root side of a finger at the body 10 side of equipment. Therefore, LED31 and a photo transistor 32 will be arranged along the die-length direction of a finger, among those LED31 is located in the tip side of a finger, and a photo transistor 32 is located in the direction of the root of a finger. Thus, when it arranges, it is effective in the ability of outdoor daylight not to reach a photo transistor 32 easily.

[0025] In the sensor unit 30 for pulse wave detection, with the translucent plate 34 which becomes the top-face part (substantial pulse wave signal detecting element) of the sensor frame 36 from a glass plate, the light transmission aperture was formed and, as for LED31 and a photo transistor 32, the luminescence side and the light-receiving side are turned to the direction of a translucent plate 34 to this translucent plate 34, respectively. For this reason, if a finger front face is stuck on the outside front face 341 (the contact surface / sensor side on the front face of a finger) of a translucent plate 34, while LED31 emits light towards a finger front-face side, a photo transistor 32 can receive the light reflected from a finger side among the light which LED31 emitted. Here, the outside front face 341 of a translucent plate 34 has structure projected from the perimeter part 361 at the purpose which raises the adhesion on the outside front face 341 of a translucent plate 34, and the front face of a finger.

[0026] In this example, as LED31, blue LED of an InGaN system (indium-gallium-nitrogen system) is used, the emission spectrum has a luminescence peak in 450nm, and the luminescence wavelength field is located in the range from 350nm to 600nm. It is made to correspond to LED31 which has this luminescence property, and in this example, as a photo transistor 32, the photo transistor of a GaAsP system (gallium-arsenic-Lynn system) is used, the light-receiving wavelength field of a component own [the] has a main sensibility field in the range from 300nm to 600nm, and a sensibility field is in 300nm or less.

[0027] Thus, the root of a finger is equipped with the constituted sensor unit 30 for pulse wave detection with the band 40 for sensor immobilization, if light is irradiated towards a finger in this condition from LED31, this light will reach a blood vessel, a part of light will be absorbed by the hemoglobin in blood, and a part will reflect by it. The light reflected from the finger (blood vessel) is received by the photo transistor 32, and the light income change is equivalent to blood volume change (pulse wave of blood). That is, if blood volume decreases while the reflected light becomes weak, when there is much blood volume, since the reflected light will become strong, a pulse rate etc. is measurable if change of reflected light reinforcement is detected.

[0028] In this example, the light-receiving wavelength field has used the photo transistor 32 of the range from 300nm to 600nm with LED31 which has a luminescence wavelength field in the range from 350nm to 600nm, and biological information is displayed based on the detection result in the wavelength field from about 300nm to about 600nm which is the lap field, i.e., wavelength field about 700nm or less. If this sensor unit 30 for pulse wave detection is used, among the light by which outdoor daylight is contained in outdoor daylight in the exposed part of a finger, as for light 700nm or less, a wavelength field will make a finger a transparent material, and even a photo transistor 32 (light sensing portion) will not be reached. It is because the wavelength field where the reason is included in outdoor daylight does not arrive to a photo transistor 32 through a finger even if outdoor daylight is irradiated by the part of the finger which is not covered in the band 40 for sensor immobilization since light 700nm or less cannot tend to penetrate a finger easily. On the other hand, if LED which has a luminescence peak, and the photo transistor of a silicon system are used near 880nm, the light-receiving wavelength range will reach the range from 350nm to 1200nm. In this case, since a pulse wave will be detected based on the detection result by light with a wavelength of 1 micrometer which reaches even a light sensing portion easily by making a finger into a transparent material, the incorrect detection resulting from fluctuation of outdoor daylight tends to take place.

[0029] Moreover, since pulse wave information has been acquired using the light of wavelength field about 700nm or less, the S/N ratio of the pulse wave signal based on blood volume change is high. As the reason, since it is large several times to about 100 or more times and wavelength

changes with sensibility sufficient to blood volume change as compared with the absorbancy index to the light whose wavelength whose absorbancy index to the light from 300nm to 700nm is the conventional detection light is 880nm, the hemoglobin in blood is considered with since the detection ratio (S/N ratio) of the pulse wave based on blood volume change is high.

[0030] As shown in drawing 5 , (Configuration of a control section) To a control section 5 The pulse wave data-processing section 55 which asks for a pulse rate etc. based on the input result from the sensor unit 30 for pulse wave detection, The pitch data-processing section 56 which asks for a pitch based on the input result from the body motion sensor 90 is constituted. The pitch data-processing section 56 and the pulse wave data-processing section 55 By outputting information, such as a pitch and a pulse rate, the display of this information to a liquid crystal display 13 is enabled. In addition, a part of pitch data-processing section 56 and pulse wave data-processing section 55 consist of microcomputers which operate by the program stored, and the block diagram has shown it to drawing 5 about the function of this microcomputer.

[0031] First, in the pulse wave data-processing section 55, after pulse wave signal magnification and a transducer 551 amplify the signal inputted through the cable 20 from the sensor unit 30 for pulse wave detection, it changes into a digital signal and outputs to the pulse wave signal storage section 552. The pulse wave signal storage section 552 is RAM which memorizes the pulse wave data changed into the digital signal. The pulse wave signal operation part 553 reads the signal memorized by the pulse wave signal storage section 552, performs the fast Fourier transform (FFT processing) as frequency analysis to it, and inputs the result into the pulse wave component extract section 554. The pulse wave component extract section 554 extracts a pulse wave component from the input signal from the pulse wave signal operation part 553, outputs it to the pulse rate operation part 555, and this pulse rate operation part 555 calculates a pulse rate by the frequency component of the inputted pulse wave, and it outputs that result to a liquid crystal display 13.

[0032] Moreover, in the pitch data-processing section 56, after body motion signal magnification and a transducer 561 amplify the signal inputted from the body motion sensor 90, it changes into a digital signal and outputs to the body motion signal storage section 562. The body motion signal storage section 562 is RAM which memorizes the body motion data changed into the digital signal. The body motion signal operation part 563 reads the signal memorized by the body motion signal storage section 562, performs the fast Fourier transform (FFT processing) as frequency analysis to it, and inputs the result into the body motion component extract section 564. The body motion component extract section 564 extracts a body motion component from the input signal from the body motion signal operation part 563, outputs it to the pitch operation part 560, and this pitch operation part 560 calculates a pitch by the inputted frequency component of a body motion, and it outputs that result to a liquid crystal display 13.

[0033] (Configuration of pitch operation part) In the pitch operation part 560 The signal which has power in the field more than a predetermined frequency more than predetermined level as a criteria wave for asking for a pitch Whether there is any signal of the high level which has the signal specification section 565 to specify, the 1st wave check section 566 which judges whether there is any signal of the high level which has the frequency which corresponds by 1/3 time the frequency of a criteria wave, and the frequency which corresponds by 2/3 time the frequency of a criteria wave The 2nd wave check section 567 to judge is constituted. furthermore, when it judges that there is no signal of the high level which has the frequency on which the 1st wave check section 566 corresponds by 1/3 time the frequency of a criteria wave in the pitch operation part 560 The signal distinction section 569 which judges a criteria wave to be the 2nd higher harmonic over the fundamental wave of a body motion is constituted. This signal distinction section 569 Also when the 2nd wave check section 567 judges that there is no signal of a high level in the location of the frequency which corresponds by 2/3 time the frequency of a criteria wave, it is constituted so that a criteria wave may be judged to be the 2nd higher harmonic over the fundamental wave of a body motion.

[0034] moreover, even when a criteria wave is judged to be the 3rd higher harmonic over a fundamental wave based on the check result of the 1st wave check section 566 and the 2nd wave check section 567, the signal distinction section 569 When it judges that it concludes that a

criteria wave is the 3rd higher harmonic wave over a fundamental wave, and a criteria wave is below in predetermined frequency level for the first time when a criteria wave judges that it is more than predetermined frequency level, it is constituted so that it may conclude that a criteria wave is the 2nd higher harmonic wave over a fundamental wave.

[0035] In the constituted pitch operation part 560, thus, the signal outputted from the body motion signal operation part 563 and the body motion component extract section 564 [it has the spectrum as shown in drawing 6 (a) and (b), and / in quest of this spectrum to a pitch] the pitch operation part 553 It judges whether it is in a walk condition automatically from the difference between the spectrum at the time of a walk, and the spectrum at the time of transit, and whether it is in a run state, and asks for a pitch by performing the operation which was suitable in each case.

[0036] The principle is as follows. First, as compared with line spectrum SA1 corresponding to a fundamental wave, drawing 6 (a) is the typical spectrum at the time of transit, and its line spectrum SA2 which line spectrum SA1 corresponding to the fundamental wave of a body motion and line spectrum SA2 equivalent to the 2nd harmonic content to the fundamental wave of a body motion appear, among those is equivalent to the 2nd harmonic content is [level is remarkable and] high. It is because vertical movement comes out equally when the step of the left leg is carried out to the time of carrying out the step of the right leg at the time of transit, so the 2nd higher harmonic of a body motion component appears. Moreover, although the fundamental wave of the swing of an arm is equivalent to pendulum movement which makes a start and pull back of an arm a round term, only a part with it difficult [to make the swing of an arm smooth pendulum movement] at the time of transit is because the power of the fundamental wave of the swing of an arm becomes weakness. Furthermore, since acceleration is applied to the start of an arm, and each moment of pull back, the 2nd higher harmonic is because it comes out more strongly than the fundamental wave of the swing of an arm.

[0037] On the other hand, drawing 6 (b) is the typical spectrum at the time of a walk, and line spectrum SB1 corresponding to the fundamental wave of a body motion, line spectrum SB2 equivalent to the 2nd harmonic content to the fundamental wave of a body motion, and line spectrum SB3 equivalent to the 3rd harmonic content to the fundamental wave of a body motion appear. At the time of this walk, the signal component to which there is no vertical movement in a body motion, and the time of transit originates in a gesture appears strongly, and that description appears in line spectrum SB1 corresponding to a fundamental wave. Consequently, although the ratio of each line spectrums SB1, SB2, and SB3 is not fixed, as compared with the time of transit, the ratio of line spectrum SB1 to line spectrum SB2 is strong at the time of a walk. Therefore, line spectrum SB1 corresponding to the fundamental wave of a body motion and line spectrum SB3 equivalent to the 3rd harmonic content have level higher than line spectrum SB2 equivalent to the 2nd harmonic content.

[0038] And line spectrum SA2 corresponding to the 2nd higher harmonic at the time of transit, line spectrum SB2 corresponding to the 2nd higher harmonic at the time of a walk, and line spectrum SB3 corresponding to the 3rd higher harmonic at the time of a walk usually appear in the above frequency domain by /100 times. Therefore, the above frequency domain is supervised by /100 times, and if it judges whether the signal of a high level is the 2nd higher harmonic over a fundamental wave among the signals which appeared there, and whether it is the 3rd higher harmonic, it can distinguish whether it is in a run state, and whether it is in a walk condition. That is, at the time of a walk, since the 3rd higher harmonic wave over a fundamental wave appears in the above frequency domain as a signal of a high level by /100 times, if it can judge that this signal is the 3rd higher harmonic wave, the pitch at the time of a walk can be calculated from the value which hung 2/3 time on the frequency of this signal. On the contrary, at the time of transit, since the 2nd higher harmonic wave over a fundamental wave appears in the above frequency domain as a signal of a high level by /100 times, if it can judge that this signal is the 2nd higher harmonic wave, it can ask for the pitch at the time of transit from the frequency of this signal.

[0039] Then, the pitch operation part 560 performs processing based on the flow chart shown in drawing 7 using the difference between the pattern at the time of transit of this spectrum, and

the pattern at the time of a walk, and asks for a pitch.

[0040] First, at a step ST 1, the highest signal (line spectrum) of level is found from the spectrum after a frequency analysis. This signal is the candidate of the signal which should serve as a criteria wave for asking for a pitch. At a step ST 2, the frequency of this criteria wave judges [100 times] whether it is above by /.

[0041] Here, 100 times, if the frequency of a criteria wave is the following by /, it will find another candidate in a step ST 3, and it finds a signal with the highest level as a criteria wave out of the signal except a previous signal in a step ST 4. When a suitable signal is not found, in this processing, in a step ST 5, the pitch measured last time is made into this pitch as it is, and this value is decided as a pitch in a step ST 6.

[0042] On the other hand, if the signal of the above high level is found by /100 times while performing processing at steps ST3 and ST4, it will judge whether there is any signal which makes this signal a criteria wave, and has a frequency 1/3 time the frequency of this criteria wave at a step ST 7, and has the amplitude of 1/2 twice or more to criteria wave amplitude.

[0043] When it has the frequency which corresponds by 1/3 time the frequency of a criteria wave at a step ST 7 and there is no signal of the amplitude of 1/2 twice or more to criteria wave amplitude, in a step ST 8, it judges whether there is any signal which has the frequency which corresponds by 2/3 time the frequency of a criteria wave, and has the amplitude of 1/2 twice or more to criteria wave amplitude.

[0044] If it has the frequency which corresponds by 1/3 time the frequency of a criteria wave at a step ST 8 and there is no signal of the amplitude of 1/2 twice or more to criteria wave amplitude, since a criteria wave can be judged to be a signal equivalent to the 2nd harmonic content, it will decide this value as a pitch as it is in a step ST 6.

[0045] On the other hand, in a step ST 7, when it has the frequency which corresponds by 1/3 time the frequency of a criteria wave and there is a signal of the amplitude of 1/2 twice or more to criteria wave amplitude, in a step ST 9, it judges whether the frequency of this criteria wave is above by 150 times/. This 150 time, the value of a part for /was a 1.5 times [for /] as many 100 times numeric value as this, in the usual case, the pitch during a walk was a part for part [for 100 times/-], and 150 times/, and 150 times, a part for /-, and 200 times, since the pitch under transit was a part for /, it was used for reconfirmation of a walk condition or a run state bordering on the numeric value of a part for /150 times. Therefore, in a step ST 9, when the frequency of a criteria wave judges that it is above by /150 times, this criteria wave can be checked as it is the 3rd higher harmonic over the fundamental wave at the time of a walk. So, since it can be concluded that a criteria wave is a signal equivalent to the 3rd harmonic content, in a step ST 10, it doubles the frequency of this signal 2/3, and decides as a pitch this value doubled 2/3 in a step ST 6.

[0046] Moreover, even when it has the frequency which corresponds by 1/3 time the frequency of a criteria wave in a step ST 7 and there is no signal of the amplitude of 1/2 twice or more to criteria wave amplitude, it sets to a step ST 8. When it is judged that it has the frequency which corresponds by 2/3 time the frequency of a criteria wave, and there is a signal of the amplitude of 1/2 twice or more to criteria wave amplitude In a step ST 9, when it judges whether the frequency of this criteria wave is above by 150 times/and the frequency of a criteria wave judges that it is above by /150 times, this criteria wave can be checked as it is the 3rd higher harmonic over the fundamental wave at the time of a walk. So, since it can be concluded that a criteria wave is a signal equivalent to the 3rd harmonic content, in a step ST 10, it doubles the frequency of this signal 2/3, and decides as a pitch this value doubled 2/3 in a step ST 6.

[0047] However, in a step ST 9, if the frequency of this criteria wave is the value of the following by 150 times/, it can be judged that a criteria wave is not a signal equivalent to the 3rd harmonic content. Therefore, the signal which has one 1/3 time of this criteria wave or 2/3 time the frequency of this is a noise to the last, and it can be judged that a criteria wave is the 2nd harmonic content. Therefore, in a step ST 6, this value is decided as a pitch as it is.

[0048] Thus, when there is no signal of the amplitude of 1/2 twice or more in the location of the frequency which there is no signal of the amplitude of 1/2 twice or more in the location of the frequency which corresponds by 1/3 time the frequency of a criteria wave to criteria wave

amplitude, and is equivalent to it 2/3 time of the frequency of a criteria wave to criteria wave amplitude, a criteria wave is judged to be the 2nd higher harmonic. However, if they are noises even when the signal of the amplitude of 1/2 twice or more is in the location of the frequency which the signal of the amplitude of 1/2 twice or more is in the location of the frequency which corresponds by 1/3 time the frequency of a criteria wave to criteria wave amplitude, or corresponds by 2/3 time the frequency of a criteria wave to criteria wave amplitude, it will be judged that it is the 3rd higher harmonic accidentally. If the pitch at the time of a walk is in the range for /at all a part for /-, and 150 times 100 times, in this example, usually then, the 3rd higher harmonic at the time of a walk As a frequency appearing to the above field by /150 times, the frequency of a criteria wave judges [150 times] whether it is above by /, and when the frequency of a criteria wave judges that it is above by /150 times, it is concluded that a criteria wave is the 3rd higher harmonic for the first time.
[0049] (Actuation of a portable electronic device) Since the portable electronic device 1 of this example is further switched to clock mode, stop watch mode, the pulsometer mode that combines with a time check and measures pulse wave information, and the mode which measures a pitch, it explains each mode of the portable electronic device 1 of this example.
[0050] The contents of a display in each mode performed with a portable electronic device 1 and the liquid crystal display 13 at that time are typically expressed to drawing 8 .
[0051] In drawing 8 , a step ST 11 is in clock mode, the purport which are December 6, 1994 and Monday is displayed on the 1st segment viewing area 131, and the purport whose current time is 10:08 p.m. 59 seconds is displayed on the 2nd segment viewing area 132. It is displayed on the dot viewing area 134 as "TIME" noting that the current mode is clock mode. However, in the dot viewing area 134, for several seconds immediately after choosing this clock mode is displayed as "TIME" as mentioned later. In addition, nothing is displayed on the 3rd segment viewing area 133.
[0052] In the portable electronic device 1 of this example, if the button switch 111 which is in a direction at 2:00 is pushed at the time of clock mode, when 1 hour passes, for example, an alarm sound can be generated, and the generating time of day of this alarm can be set as arbitration. Moreover, if the button switch 113 which is in a direction at 11:00 is pushed, EL back light of a liquid crystal display 13 will light up for 3 seconds, and the light will be put out automatically after an appropriate time.
[0053] If the button switch 112 which exists in the direction of 4:00 from this mode is pushed, it will switch to running mode (step ST 12). This mode is the mode when using a portable electronic device 1 as stop watch. In running mode, before starting measurement (standby condition), current time is displayed on the 1st segment viewing area 131, and it is displayed on the 2nd segment viewing area 132 as "0:00':00":00." In the dot viewing area 134, a graphic switches, after displaying for 2 seconds as "RUN" as guidance of the purport which is in running mode.
[0054] If the button switch 112 which exists in the direction of 4:00 from this mode is pushed, it will switch to the recall mode (step ST 13) of a lap time. This mode is the mode which reads the lap time measured in the past using the portable electronic device 1, and split time. In the recall mode of a lap time, the date is displayed on the 1st segment viewing area 131, and current time is displayed on the 2nd segment viewing area 132. For 2 seconds is displayed on the dot viewing area 134 as "LAP/RECALL" as guidance of the purport which is in recall mode, next transition of the pulse rate for every newest lap is displayed on it.
[0055] If the button switch 112 which exists in the direction of 4:00 from this mode is pushed, it will switch to the recall mode (step ST 14) of a pulse wave measurement result. This mode is the mode which reads the temporal response of the pulse rate which the marathon performed in the past used the portable electronic device 1 at the time, and was measured and memorized, and the temporal response of the pitch measured in the past using the portable electronic device 1. In this recall mode, the date is displayed on the 1st segment viewing area 131, and current time is displayed on the 2nd segment viewing area 132. The graph with which for 2 seconds is displayed as "RESULT/RECALL", next the temporal response of an average pulse rate is expressed is displayed on the dot viewing area 134.
[0056] If the button switch 112 which exists in the direction of 4:00 is again pushed from this

mode, as an arrow head P1 shows, it will return to clock mode (step ST 11). Moreover, in steps ST12-ST14, also when the condition that there is no input continues for 10 minutes, as an arrow head P2 shows, it returns to clock mode (step ST 11) automatically. When it returns to this clock mode, the date is displayed on the 1st segment viewing area 131, and current time is displayed on the 2nd segment viewing area 132.

[0057] Although it is displayed as "TIME" noting that it returns to clock mode so that it may expand to the dot viewing area 134 at drawing 9 (a) when it becomes clock mode in this example, and it may be shown, as this annunciator is shown in drawing 9 (b), it will disappear automatically after 2 seconds, and it will be in the normal state (step ST 15) in clock mode. In the normal state in this clock mode, it is still the condition that nothing is displayed on the dot viewing area 134. That is, power-saving is attained by only necessary minimum time amount's indicating by the dot showing a user to the mode, and considering as the mode display of the purport that whose that has disappeared itself it is the normal state in clock mode.

[0058] In the portable electronic device 1 of this example, if it equips with the connector piece 80 to a connector area 70, as an arrow head P3 shows to drawing 8 , it will switch from any condition to running mode (step ST 12) automatically. The running mode at this time not only operates as stop watch, but is the mode which can measure the pitch and pulse rate under running.

[0059] With reference to the function in the running mode as pitchometer and pulsometer, it explains focusing on drawing 10 .

[0060] First, in drawing 10 , if it switches to the running mode as pitchometer and pulsometer (step ST 31), as shown in drawing 11 (a), current time will be displayed on the 1st segment viewing area 131 of a liquid crystal display, and it will be displayed on the 2nd segment viewing area 132 as "0:00':00":00", and will be displayed on the dot viewing area 134 as "RUN." Moreover, it indicates that the mark of the heart blinked by the 3rd segment viewing area 133, and it switched to the running mode as pitchometer and pulsometer.

[0061] Power is supplied to the pulse wave data-processing section 55 etc. by switch in this mode, and initialization processing called a setup of a period of operation etc. is performed by it. And incorporation of the pulse wave signal for measuring an early pulse rate after 2 seconds is performed. the display (step ST 32) with "STOP/5" and the display (step ST 33) with "MOTION/4" are performed to the dot viewing area 134 by turns, and seem not to move by 2Hz to it for 5 seconds at this time -- ** -- it is displayed. The figure displayed at this time is the count-down to for 5 seconds, and switches. And it will be in a standby condition until the button switch 117 located in the body of equipment 10 front-face bottom is pushed so that measurement of time amount may be started (step ST 34).

[0062] In the state of this standby, as shown in drawing 11 (b), graphical display of the original wave of a pulse wave signal is carried out to the dot viewing area 134. The original wave displayed here is the newest data. Therefore, if the wave of a original wave of a pulse wave signal and level are checked before starting measurement (marathon) of time amount, the quality of the wearing condition of LED31 or a photo transistor 32 can be distinguished in detail. Moreover, the location of LED31 or a photo transistor 32 can also be set as the optimal location by adjusting LED31 and a photo transistor 32, checking the configuration and level of a original wave. And it can check beforehand whether it is the environment which can measure surrounding temperature and humidity. Furthermore, this function is applicable to the inspection etc. at the time of manufacture of a portable electronic device 1. Moreover, since graphical display of the original wave is carried out, it can also check whether the time-axis has been changed by consumption of a cell etc. In addition, the early pulse rate "75" for which it asked from pulse conversion is displayed on the 3rd segment viewing area 132.

[0063] While measurement of elapsed time will be started from this condition if the button switch 117 located in the body of equipment 10 front-face bottom is pushed at the same time it starts marathon, measurement of a pitch and a pulse rate is performed (step ST 35).

[0064] As these measurement results were shown in drawing 12 (a), first, elapsed time is displayed on the 2nd segment viewing area 132, and graphical display of the temporal response of a pulse rate is carried out to the dot viewing area 134. The graphical display performed at this

time is a display by the bar graph prolonged in the upper part from a lower part by making the abbreviation mid-position of an axis of ordinate into a pulse rate 65. In the meantime, the graduation and the pulse rate at the time of the axis of ordinate of the graph displayed on the dot viewing area 134 are displayed on the 3rd segment viewing area 133.

[0065] When a pulse rate enters in a range (assignment within the limits to pulse rates 120-168), as it is shown in drawing 12 R> 2 (b) in this condition, graphical display of the pulse rate is carried out as a difference over the criteria pulse rate set up beforehand (step ST 36). The graphical display performed at this time is a display by the bar graph prolonged in the upper and lower sides (forward and the negative direction) in the part which is equivalent to a difference from this value by making the abbreviation mid-position of an axis of ordinate into a pulse rate 150. Moreover, the mark which shows the appointed range of a pulse rate is displayed on the right-hand side edge of the dot viewing area 134.

[0066] A push on the button switch 114 which is in a direction at 8:00 in the meantime carries out graphical display of the temporal response of a pitch to the dot viewing area 134 (step ST 37). The graphical display performed at this time is the line graph which made the pitch 170 the abbreviation mid-position of an axis of ordinate, as shown in drawing 12 (c). At this time, the graduation (purport whose abbreviation mid-position of an axis of ordinate is the pitch 170) and the pitch at the time of the axis of ordinate of the graph displayed on the dot viewing area 134 are displayed on the 3rd segment viewing area 133. Thus, in the portable electronic device 1 of this example, in the dot viewing area 134, since it has displayed with a different gestalt from the display of a pulse rate called a line graph etc. in the temporal response of a pitch, a runner can distinguish easily whether the current display shows which information only by seeing the display gestalt.

[0067] If the button switch 114 which is in a direction at 8:00 is again pushed from this condition, it will return to the condition (step ST 36) that the temporal response of a pulse rate is displayed on the dot viewing area 134.

[0068] Moreover, if the button switch 116 located in the body of equipment 10 front-face bottom is pushed when it passes along a predetermined shunt, the lap time at that time will be displayed on the 1st segment viewing area 131 (step ST 38). And after 10 seconds, it returns to a step ST 36 automatically.

[0069] If the button switch 117 located in the body of equipment 10 front-face bottom is pushed at the same time it reaches gall after an appropriate time, measurement of a pulse rate, a pitch, and time amount will stop, and it will be displayed on the dot viewing area 134 as "COOLING/DOWN" (step ST 39). If 2 minutes pass since this condition, graphical display of the temporal response of the pulse rate after making a goal will be carried out to the dot viewing area 134 as a pulse recovery property (step ST 40).

[0070] The graphical display about this pulse recovery property switches to the bar graph display prolonged upwards from the bottom first with the graduation which made the abbreviation mid-position of an axis of ordinate the pulse rate 150, as shown in drawing 13 (a). And as shown in drawing 13 (b), the recovery property for 2 minutes is measured. In the meantime, the graduation and the pulse rate at the time of the axis of ordinate of the graph displayed on the dot viewing area 134 are displayed on the 3rd segment viewing area 133.

[0071] If the button switch 114 which is in a direction at 8:00 is pushed from this condition, after being displayed on the dot viewing area 134 as "PULSE/RESULT" for 1.5 seconds (step ST 41), the temporal response of the pulse rate in this marathon will be displayed on the dot viewing area 134 (step ST 42). Moreover, if the button switch 114 which is in a direction at 8:00 is pushed, after being displayed on the dot viewing area 134 as "PITCH/RESULT" for 1.5 seconds (step ST 43), the temporal response of the pitch in this marathon will be displayed on the dot viewing area 134 (step ST 44). Furthermore, if the button switch 114 which is in a direction at 8:00 is pushed, after being displayed on the dot viewing area 134 as "COOLING/DOWN" for 1.5 seconds (step ST 45), it will return to the condition (step ST 40) that graphical display of the temporal response of the pulse rate after reaching the dot viewing area 134 is carried out as a pulse recovery property.

[0072] After making a goal, when the button switch 116 located in the body of equipment 10 front-face bottom is pushed, in addition, to the dot viewing area 134 If guidance

"PROTECT/MEMO?Y" of whether to memorize this result is displayed (step ST 46), the button switch 117 located in the body of equipment 10 front-face bottom is pushed and "YES" is answered It is displayed on it as "MEMORY" noting that a result is storage processed in the dot viewing area 134 (step ST 47), and after 2 seconds, it returns to an initial state (step ST 31).

[0073] If the button switch 112 which exists in the direction of 4:00 is pushed after the measurement as this pitchometer and pulsometer is completed, as shown in drawing 8 , it will switch to the recall mode (step ST 13) of a lap time. If the button switch 112 which exists in the direction of 4:00 is pushed from this mode, it will switch to the recall mode (step ST 14) of a pulse wave measurement result. Also in this mode, graphical display of the temporal response of a pitch and a pulse rate can be carried out to the dot viewing area 134. If the button switch 112 which exists in the direction of 4:00 is pushed from this condition, it will return to clock mode (step ST 11).

[0074] Also when it returns to this mode, the date is displayed on the 1st segment viewing area 133, and current time is displayed on the 2nd segment viewing area 132. Moreover, although an annunciator with "TIME" is performed to the dot viewing area 134 noting that it returns to clock mode, as an arrow head P4 shows, after 2 seconds, this display will disappear automatically and will be in the normal state (step ST 15) in clock mode.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] They are the whole portable electronic device configuration concerning one example of this invention, and the explanatory view showing a busy condition.

[Drawing 2] It is the top view of the body of equipment of the portable electronic device shown in drawing 1 .

[Drawing 3] It is an explanatory view when seeing the body of equipment of the portable electronic device shown in drawing 1 from the direction of 3:00 of a wrist watch.

[Drawing 4] It is the sectional view of the sensor unit for pulse wave detection used for the portable electronic device shown in drawing 1 .

[Drawing 5] It is the block diagram showing a part of function of the control section (pulse wave data-processing section and pitch data-processing section) of the portable electronic device shown in drawing 1 .

[Drawing 6] It is an explanatory view for explaining the principle which asks for a pitch in the portable electronic device shown in drawing 1 , and the spectrum obtained by (a) carrying out frequency analysis to the body motion signal acquired at the time of transit and (b) are the spectrum obtained by carrying out frequency analysis to the body motion signal acquired at the time of a walk.

[Drawing 7] It is the flow chart which shows the actuation in the pitch operation part of the pitch data-processing section shown in drawing 5 .

[Drawing 8] It is the explanatory view showing each mode of the portable electronic device shown in drawing 1 .

[Drawing 9] The explanatory view showing an annunciator when clock mode is chosen among the modes which show (a) in drawing 8 , and (b) are the explanatory views showing the condition that this annunciator disappeared.

[Drawing 10] In the portable electronic device shown in drawing 1 , it is an explanatory view for explaining the function in the running mode as pitchometer and pulsometer.

[Drawing 11] The explanatory view showing the contents of the display when (a) switched to the running mode as the pitchometer shown in drawing 10 and pulsometer, and (b) are the explanatory views showing the contents of the display before starting measurement in this mode.

[Drawing 12] The explanatory view in which the explanatory view showing the display gestalt before a pulse rate reaches in a predetermined range after starting measurement of a pulse rate in the running mode as the pitchometer which shows (a) to drawing 11 , and pulsometer, and (b) show the display gestalt after the pulse rate reached in a predetermined range, and (c) are the explanatory views showing a display gestalt in case the temporal response of a pitch is shown.

[Drawing 13] After (a) had actuation of stopping measurement of a pulse rate, in the portable electronic device shown in drawing 1 , the explanatory view showing a display gestalt in case a pulse rate is in a predetermined range, and (b) are the explanatory views showing a display gestalt when a pulse rate separates out of a predetermined range.
[Drawing 14] The wave form chart after (a) carries out pulse conversion of the body motion signal in the conventional pitchometer, and (b) are the wave form charts for explaining the mask at the time of counting a pulse in the conventional pitchometer.
[Description of Notations]
1 ... Portable electronic device (pitchometer)
5 ... Control section
10 ... Body of equipment
12 ... Wristband
13 ... Liquid crystal display
30 ... Sensor unit for pulse wave detection
31 ... LED
32 ... Photo transistor
55 ... Pulse wave data-processing section
56 ... Pitch data-processing section
90 ... Body motion sensor
560 ... Pitch operation part